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* ILLUSTRATED ARTICLES.

RATIONAL LOCOMOTIVE REPAIR RECORDS.

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The primary object of accounting, as applied to the affairs of a railway company or other business corporation, is that of comparing the receipts and disbursements during successive periods, and determining its financial condition. A mere statement, however, of the money earned and spent, while necessarily the most important, is not sufficient for the requirements of any large concern, and an elaborate system of statistical accounts has, during the past few years, been developed on every road, which are less directed to a statement of moneys earned and spent than to a detailed analysis of the various expenditures, which together make up the periodical disbursements of a railroad company, and a determination of the corresponding work accomplished. These statements enable consecutive comparisons to be made, show the degree of economy with which the various services are carried on, and indicate the lines along which further economies may be effected, and their efficiency is measured by the clearness with which the information is presented and the accuracy of the relation between the costs and the work performed.

From the standpoint of a manager or operating official the statements that are prepared, showing the cost per day, per mile, or per ton mile, of the various items that enter into the total cost of transportation are, no doubt, satisfactory. They enable him to detect any undue increase in the cost of one or more individual details, and take the necessary steps to ascertain its cause; but while an operating official is thus informed amongst other figures of the cost of his motive power, the motive power official does not, as a rule, obtain any further analysis to enable him to assign a definite reason for the variations in his monthly results or determine to what extent they are serious and permanent. In making this statement no reference is intended to detail accounts, such as those showing from time to time the cost of making parts of locomotives or cars, or to payroll statements in their various forms; such accounts all roads have, and they are of great value, but a general analysis of the cost of maintenance, which may vary considerably from month to month, is not usually attempted, and the present article is intended to discuss the lines along which it may be developed.

The monthly cost of maintenance of locomotives is, properly speaking, not a single account, although it is usually treated as one, and it is chiefly for this reason that most of the attempts to make an intelligent analysis of it have failed. Its amount for each month does not necessarily bear any relation to the mileage made by the engines during that month, and, in fact, is frequently to a certain extent inversely proportional to it. Many conditions affect the cost per mile to a greater extent than does the management of the department, and the latter has occasionally obtained credit for results for which it was only slightly responsible, or been blamed when it was not in any way at fault. When a road is purchasing a large amount of new power and scrapping a corresponding amount of old, the costs will show a great reduction, whether any actual improvements in maintenance methods are made or not, and when this transition comes to a stop the costs will increase, and very possibly to an extent far greater than any reduction that could be effected by the most complete revolution in shop or roundhouse methods. While, then, to a manager the cost of repairs per mile or per ton mile is a figure that must be carefully watched, this figure is not for a particular month of any great value to a motive power officer, other than on account of the necessity imposed on him of keeping within such limits as will be acceptable to his superior officer, and its amount from month to month does not accurately inform him as to whether or not the results he is obtaining are satisfactory or enable him to compare them with those he previously realized.

As an example to illustrate the statement made, that the cost of maintenance of locomotives is not properly a single account, an allied expenditure for which the motive power department is generally held responsible, cost of roundhouse men may be considered. The amount of this should very properly be proportional to the mileage run in any month, as the force employed should depend on the number of engines dispatched, which corresponds very closely. It is true that if two hostlers are employed at a point and dispatch 1,000 engines one month, they cannot each be reduced to 0.9 of a hostler if 900 engines only are dispatched the next, but, on the whole, with a reduction in mileage some reduction may be made in the force, and vice versa. The expense will also vary somewhat in winter and summer, and is, of course, affected by rates, schedules, etc., but, on the whole, this is very properly a single monthly account, which can be properly compared on the basis of the mileage made by engines during each month

and watched from month to month, or from year to year accordingly. Each month is complete in itself, and a reduction in one month does not result in work being carried over to the next to any appreciable extent.

The maintenance of locomotive account is very different. A reduction in force may be ordered for some of the various reasons that induce that decision, or engines may have been worked up into condition for a temporary heavy business and the shop staff reduced. The engines go on making mileage, however, and the result is a low cost of repairs for the month. No real reduction has been made in the cost of repairs per mile, but the proportion of work that should have been done in that month has been anticipated or has simply been carried over and will have to be done later. If in the latter case the reduction is carried too far, the condition of the power may be affected, and a heavier expense incurred than had it been properly maintained. In any event, it is evident that a portion, at any rate, of the cost of maintenance has no relation to the mileage made in the corresponding month in the sense that the cost of roundhouse labor does.

There are, in reality, two factors entering into the cost of maintenance of locomotives, one of which may be termed the cost of running repairs, the other that of shop repairs. The first is a charge very similar in its nature to that of roundhouse men; it is properly a monthly charge, and varies in the same way with the mileage run. It is true that if running repairs are neglected, the condition of power will depreciate, but for equally good maintenance it is comparable from month to month, and its amount should vary in proportion to the mileage run, or the number of trips made by the engines, with due allowance for their character and the season of the year.

The second factor, the cost of shop repairs, is a charge of a very different nature; with no change in the actual cost of maintaining the power, it will vary from month to month, dependent chiefly on the amount of money devoted each month to shop repairs, and the amount of mileage run, but these figures are not necessarily proportional. Over a period of several months it is an indication of the economy with which the power is maintained, provided no change takes place in the condition of the power, no power is bought or scrapped, or that these factors are identical in the period with which comparison is to be made.

The cost of shop repairs must evidently be looked at somewhat differently from an account like running repairs or roundhouse men, and it is necessary to investigate what it actually represents. In each month a certain number of engines are passed through the shops for repairs. Each one has run a certain number of miles since previously receiving repairs, and the cost of repairing it is the cost of its shop repairs for the miles it has run since it last received repairs. Similarly for all the engines shopped in any one month the cost of the shop repairs for that month represents the costs of their shop repairs for the miles they have run since their last overhauling. The cost of shop repairs, then, in any month divided by the mileage made since last overhauling by the engines receiving repairs during that month represents the cost per mile for shop repairs for those engines. They are, of course, only a small proportion of the equipment, but nothing can be told from one month's figures of what those engines will cost for shop repairs that have not been shopped that month; all that is known, and the one thing that is known definitely, is what the engines cost that did receive repairs.

It is evident that by dividing the cost of shop repairs in any month by the mileage made by all the engines in service, that a figure is obtained that has no real meaning, since, if 20 engines are shopped one month and 25 the next, the amount spent on shop repairs may vary considerably, and if the same number of miles be run there will be an apparent difference in shop repairs, whereas, in fact, the 25 engines may have actually cost less per mile than the 20. If, on the other hand, the cost of each engine per mile for shop repairs is obtained, based on its cost of repairs and the miles it has run since last overhauling, the sum of these costs for the month shows the cost per mile for all the engines that received repairs during that month, and as month after month one engine after another passes through the shops and receives repairs, so figures are obtained showing the cost per mile for shop repairs, and when these figures are properly grouped and arranged, it can be seen month by month whether engines of similar types are costing more or less per mile for shop repairs.

Before discussing further the general features of accounts based on this method, it will be preferable to show how they are worked out in practice, as the principle is far easier to understand when shown in this way than when discussed in the abstract. The first step is, of course, the division of the maintenance of locomotive account into running and shop repairs. By running repairs, of course, are meant those generally handled in a roundhouse; but frequently fairly heavy repairs are made there, and, on the other hand, where the shop and roundhouse are close together, repairs that are properly roundhouse work are sometimes done in the shop, especially since overhead cranes have been introduced and an engine can be lifted so cheaply. It becomes necessary, therefore, to draw some line, and this may be done to suit the personal idea of the man in charge. There are advantages, however, in basing it on the amount of labor expended, and it will be assumed that repairs costing under $100 for labor are running repairs; those costing over that amount are shop repairs.

When, as is usually the case, time and material are charged against individual engines, it is a very simple matter to compile a statement showing the cost of running repairs each month by classes of engines and operating divisions, or where the number of different classes is large, it is preferable to divide the power into groups, each consisting of several classes which are substantially similar and which should cost the same for repairs, and determine the cost for each group instead of for each class. The material and labor costs should, of course, be separated, and it is also advisable to make a division between boiler work and other work, as, owing to the large variation in the cost of boiler work that is caused by a difference in the quality of the water on different sections, where it is separated, the cost of maintenance of machinery, etc., is of more value. The separation can be readily made from the payroll without the necessity of men booking their time to anything but the engine number, and while this plan is not absolutely accurate, it should be remembered that in statistical accounting, as distinct from financial, it is substantial accuracy that is needed, not absolute; the substance is required, not the form.

A statement as above described will show the cost, miles run, and cost per mile of the various classes or groups of engines on each division, and is therefore a complete general analysis of the cost of running repairs. It has, however, one serious defect, namely, that the cost and cost per mile of any class must be looked at together to understand the influence that any variation has on the total cost of running repairs for the month. One class may have cost a large amount per mile, and yet on account of the small mileage made by the engines included in it the influence on the month's results may not be serious. To make any particular figure valuable in a statement it is necessary not only to know its individual amount, but also to estimate its bearing on the grand total, otherwise too much consideration is required to properly utilize it. This can be conveniently shown by settling on an arbitrary rate for each class, and stating by what amounts its repairs are above or below the amount established by that standard.

A convenient method of showing this is by establishing a standard rate approximating that at which the work should be performed, and by showing the amount in each month that the work done actually cost more or less than it would have cost if carried out at the standard rate. It is not necessary that the standard rate should be established with any par-

STATEMENT I.

MONTHLY STATEMENT OF COST OF RUNNING REPAIRS.
ALL DIVISIONS, MONTH OF FEBRUARY, 1905.

Group.	Rate.	Labor.		Material.		Defect.	Total.	Mileage.	Per Mile.	Excess.	Decrease.
		Boiler Work.	Other Work.	Boiler Work.	Other Work.						
A	1.9	39.74	350.34	......	99.50	......	489.58	24,898	1.92	16.52	......
B	2.4	597.74	3,991.88	45.02	1,795.74	......	6,430.38	237,248	2.71	735.41	......
C	1.8	1.37	106.27	......	31.38	36.84	175.86	10,034	1.74	......	4.75
D	2.0	168.31	926.91	2.65	523.32	122.84	1,744.13	65,323	2.67	437.67	......
E	3.0	441.15	2,486.14	11.88	1,556.74	92.06	4,587.87	123,420	3.71	885.37	......
F	3.1	149.41	2,240.37	2.27	949.99	363.14	3,706.18	114,959	3.23	142.51	......
G	3.6	158.14	2,041.94	......	602.47	58.05	2,8[illegible].60	113,739	2.52	......	1234.00
H	2.0	......	30.19	......	13.19	......	43.38	1,681	2.58	9.76	......
J	1.6	......	3.64	......	21.99	......	25.63	1,718	1.48	......	1.86
K	2.4	51.57	504.07	.60	302.97	......	859.21	70,695	1.21	......	832.00
L	2.8	61.26	324.42	.53	319.34	......	705.55	59,863	1.18	......	964.62
		1,668.69	13,006.17	62.95	6,216.63	672.93	21,628.37	823,578	2.63	......	809.99

Per 100 Per Cent. Mile, 1.93.

STATEMENT II.—GROUP X.

Month.	Engine	Rate.	Repairs.					Mileage.		Cost.			Per Mile.	Excess.	Decrease.	Total to Date.	Per Mile.
			At.	M	T	F	D	Engine.	Period.	B. W.	O. W.	Total.					
Sept..	231	1.62	Carleton Jct.	1	1	..	E	35,094	......	107.30	826.85	934.15	2.66	363.87	......	......	...
	279	...	Carleton Jct.	1	2	..	E	64,837	......	118.98	761.03	880.01	1.35	......	173.59	......	...
	393	...	Carleton Jct.	1	1	..	E	29,606	129,537	224.76	757.40	982.16	3.31	501.06	......	691.34	.53
Oct...	391	...	Carleton Jct.	1	1	..	E	65,218	......	186.48	658.94	845.42	1.3	......	214.37	......	...
	288	...	Toronto Jct.	1	1	..	O	40,228	......	233.27	970.05	1,203.32	2.99	549.62	......	......	...
	290	...	Toronto Jct.	3	2	..	O	......	......	46.80	402.30	449.10	...	449.50	......	......	...
	294	...	Toronto Jct.	1	1	..	O	73,492	308,475	97.45	957.42	1,054.87	1.44	......	139.37	1,336.72	.43
Nov...	287	...	Toronto Jct.	2	..	..	O	17,737	......	24.40	395.46	419.86	2.36	131.64	......	......	...
	293	...	Toronto Jct.	3	..	..	O	......	......	1.91	20.26	22.17	...	22.17	......	......	...
	296	...	Toronto Jct.	3	..	..	O	......	......	7.97	208.47	216.44	...	216.44	......	......	...
	298	...	Toronto Jct.	1	1	..	O	101,324	......	87.89	859.41	947.30	.93	......	699.20	......	...
	390	...	Angus.	1	1	..	E	80,582	......	237.75	1,149.34	1,387.09	1.72	77.63	......	......	...
	366	...	Carleton Jct.	1	2	..	E	60,987	......	68.99	1,011.29	1,080.28	1.77	89.26	......	......	...
	383	...	Carleton Jct.	1	1	..	E	53,728	622,833	122.03	1,214.63	1,336.66	2.48	463.58	......	1,638.24	.26
Dec...	299	...	Carleton Jct.	1	2	..	E	81,080	......	29.34	776.25	805.59	.94	......	511.96	......	...
	277	...	Carleton Jct.	1	2	1	E	40,560	......	29.33	630.17	659.50	1.62	.40	......	......	...
	379	...	Carleton Jct.	1	1	..	E	82,806	......	67.15	692.12	759.27	.91	......	586.33	......	...
	388	...	Carleton Jct.	1	1	..	E	79,646	......	117.56	802.33	919.89	1.15	......	374.36	......	...
	281	...	Carleton Jct.	1	1	..	E	83,054	989,979	119.48	1,089.39	1,209.37	1.45	......	140.27	E 25.72	...
1905. Jan...	232	...	Carleton Jct.	1	1	..	E	34,191	......	129.11	820.06	949.17	2.72	393.56	......	......	...
	292	...	Toronto Jct.	1	1	..	O	45,785	......	387.86	806.57	1,194.43	2.6	450.42	......	......	...
	293	...	Toronto Jct.	1	1	..	O	42,930	1,112,885	113.99	1,022.84	1,136.83	2.64	439.22	......	1,308.92	...
Feb...	297	...	Toronto Jct.	2	..	..	O	31,718	......	5.98	226.15	232.13	.73	......	283.30	......	...
	367	...	Carleton Jct.	1	1	..	E	97,020	......	137.04	898.30	1,035.34	1.06	......	541.23	......	...
	359	...	Carleton Jct.	1	1	..	LS	181,876	1,423,499	122.30	1,070.15	192.45	.65	......	1,763.03	D1,278.64	.70

STATEMENT III.—SUMMARY OF SHOP REPAIRS.

ALL DIVISIONS............ MONTH ENDING FEBRUARY, 1905.

Group.	Rate.	Month.							Period.						
		Mileage.	Boiler Work.	Other Work.	Total.	Per Mile.	Excess.	Decrease.	Mileage.	Boiler Work.	Other Work.	Total.	Per Mile.	Excess.	Decrease
A	1.50	6,878	37.74	151.50	189.24	2.75	86.07	......	1,188,775	6,491.37	20,431.43	26,922.80	2.26	9,091.18	......
B	1.62	310,614	265.32	2,194.60	2,459.92	.79	......	2,587.56	1,423,499	2,825.56	19,027.18	21,852.74	1.53	......	1,279.57
C	1.50	67,102	185.44	724.77	910.21	1.36	......	96.32	212,645	654.58	4,345.57	5,000.25	2.35	1,599.17	......
D	2.0	122,632	374.65	1,527.28	1,901.93	1.55	......	550.71	415,582	1,498.50	6,842.25	8,340.75	2.0	29.11	......
E	2.37	......	......	......	......	....	......	......	12,573	560.50	463.79	1,024.29	8.16	725.58	......
F	2.5	......	......	......	......	....	......	......	41,017	383.63	1,937.95	2,321.58	5.65	1,296.17	......
G	2.5	100,837	317.85	2,056.81	2,374.66	2.37	......	146.26	549,989	3,284.66	13,415.49	16,700.15	3.01	2,950.42	......
H	2.62	45,985	282.26	1,668.93	1,951.19	4.25	744.07	......	201,588	2,072.96	7,844.81	9,917.71	3.88	4,620.08	......
I	3.37	165,859	1,289.20	6,614.48	7,903.68	4.77	2,305.94	......	622,371	6,897.29	33,774.70	40,671.99	6.52	19,963.88	......
J	3.75	......	208.00	271.01	479.01	....	479.01	......	275,686	1,158.99	5,176.78	6,335.77	2.3	......	4,002.46
K	2.37	......	54.11	165.59	219.70	....	219.70	......	222,592	1,319.65	5,538.61	6,858.26	3.08	1,571.68	......
L	3.0	173,185	727.24	4,099.64	4,826.88	2.78	......	368.67	1,326,380	10,994.43	40,219.39	51,213.82	3.86	11,422.42	......
M	2.25	51,819	209.21	1,158.87	1,368.08	2.64	202.17	......	51,819	438.22	2,622.26	3,060.48	5.9	1,894.57	......
N	2.5	64,013	249.62	1,294.70	1,544.32	2.41	......	56.01	405,522	2,584.44	11,268.66	13,853.10	3.42	3,715.05	......
O	3.75	95,472	350.74	3,602.61	3,953.35	4.14	373.15	......	602,504	3,590.60	21,533.53	25,130.13	4.16	2,534.00	......
P	3.87	60,714	644.30	3,015.14	3,659.44	6.02	1,286.77	......	668,041	5,122.36	29,936.56	35,058.92	5.25	9,172.33	......
Q	4.5	......	1.22	129.35	130.57	....	130.57	......	......	29.73	677.01	706.74	....	706.74	......
R	2.5	......	......	......	......	....	......	......	......	......	......	......	....	......	......
S	2.0	......	2.73	151.11	153.84	....	153.84	......	......	2.73	151.11	153.84	....	153.84	......
T	3.0	......	......	......	......	....	......	......	333,897	1,096.51	5,925.51	7,022.02	2.1	......	2,994.89
U	3.5	29,695	355.57	1,147.87	1,503.44	5.06	464.12	......	212,675	1,470.47	6,845.37	8,315.84	3.91	872.21	......
Total...		1,294,805	5,555.20	29,974.26	35,529.46	2.74	2,639.89	......	8,767,215	......	......	290,461.64	3.31	64,052.51	......

Per 100 Per Cent. Mile, 2.70. Per 100 Per Cent Mile, 3.20.

STATEMENT IV. (PART 1.)

INDIVIDUAL RECORD OF COST OF LOCOMOTIVE REPAIRS.

RATE PER MILE RUNNING, 1.6; SHOP, 2.0. TOTAL, 3.6. GROUP B 2.

Engine No.	Division.	Total Mileage.	Running Repairs.						Intermediate Repairs.									
			Labor.		Material.		Defect.	Total.	Mach.		Tubes.		F/ /B	Labor.		Material.		Total.
			Boiler Work.	Other Work.	Boiler Work.	Other Work.			2	3	1	2		Boiler Work.	Other Work.	Boiler Work.	Other Work.	
306	E	75,275	89.41	528.57	24.05	144.42	......	786.45	1	..	..	1	..	110.35	696.00	9.24	105.70	921.29
399	O	64,180	105.86	468.31	28.25	127.03	42.15	771.60	..	1	..	..	..	12.21	37.04	2.19	13.35	64.79
303	E	80,453	121.15	589.26	31.08	140.11	......	871.60	..	..	..	..	..	......	......	......	......	......

ticular accuracy provided it divides the operations, which it is desired to compare, into those which cost more and those which cost less than its amount. But its introduction into a statement causes the items requiring attention to stand out clearly, and determines in dollars and cents, each month or period, the effect of high costs as compared with the amount which would have been spent, had these been reduced to a lower rate.

In order to obtain a coherent relation, the arbitrary rate should be based on some quantity of the engine, such as its weight or tractive power, so that for all classes a cost per engine mile per engine ton mile or per 100 per cent. mile may be obtained, and it will in this article be considered as based on the 100 per cent. engine mile, a 100 per cent. engine being one with a tractive effort of 20,000 lbs.

A sample statement for one division for one month compiled in this way is shown below, the group numbers being fictitious, the other figures those taken from an actual statement, in which the standard rate is taken at 2 cents per 100 per cent. mile. It is evident that it shows almost at a glance the relative amounts spent in maintaining the various classes, how one division varied from the other, and how important any increased or decreased cost was in relation to the total amounts spent, and while this statement only shows the month's results, it can evidently be easily arranged to show those for any desired period in addition, as for instance from the commencement of the fiscal year, and it is recapitulated on this Statement I., to show the total results on all divisions.

The statement showing the cost of shop repairs is somewhat different. If an engine after receiving a general overhauling simply received running repairs until it again came to the shops the case would be very simple, but this is not what happens. It is very general practice, on many roads at any rate on certain classes of engines, to bring an engine in for light repairs once or even twice between each general repair, and there are in addition specific shop repairs performed, such as those necessitated by broken parts, and heavy roundhouse work which may perhaps run into $200 or $300, by which a few worn out parts are repaired and further mileage obtained from the engine. It is obvious that if an engine were considered shopped when it received intermediate repairs that its cost per mile would be low, whereas when it came in and received a general overhauling its cost would be high, as there would only be the mileage since its intermediate repairs to compare with the cost of the general overhauling. If an intermediate repair costs one-half of a general repair, it is evident that if for instance an engine ran 30,000 miles and received an intermediate repair, then ran 30,000 more and received a general, it would be proper to take 20,000 miles as the proper amount on which to base the cost of the intermediate repair, leaving 40,000 on which to base the cost of the general. Intermediate repairs do not necessarily bear that relation to the general, and as the object should be to obtain results that are if anything on the safe side, it is preferable to only allow one-half of the mileage made to an intermediate repair in determining the cost per mile, leaving the other half to be used when an engine is shopped for a general overhauling. In the case of specific repairs no definite mileage can be allowed. They are liable to be required at any time, and the best way is to include their cost without allowing any mileage credit; they are items that have to be taken care of.

The principle of comparing the actual cost of running repairs with an arbitrary figure can be even more conveniently used in a shop repair statement, but an additional figure is required. One month's results in shop repairs is too variable to be of value by itself; it is necessary to know what they are over a considerable period; this can be shown by attaching to each month's results a statement showing the results for the last period of six months, including the current one. Then each statement shows for a six months' period the results obtained, and the variation in that time from the standard cost. The statement for one class of engines on this system is as follows, the repairs being classified as described in the AMERICAN ENGINEER, January, 1905, page 27, No. 1 machinery being considered as general, No. 2 machinery as intermediate, and No. 3 and defect as specific repairs, and the standard rate being based on 2½ cents per 100 per cent. mile. Statement II. illustrates this.

Such a statement shows for this class of engines just what the cost per mile for shop repairs was for the month, which engines ran above and which below the standard, how the cost and mileage of each engine affected its cost per mile, and what effect specific repairs had on the general results, and how the costs for the month compare with and affect those for the period. It is not necessary to separate engines by divisions on this sheet, as if the division is shown those requiring attention are easily noted by the excess and decrease columns. Statements similar to this made out for each class are easily recapitulated by divisions, and such a recapitulation for all classes and divisions is as shown in Statement III., which is made up for each division.

This recapitulation is in actual working the most valuable statement of the series. It shows at a glance which engines have cost above or below the average, what their cost per mile was and what effect its variation has had in dollars and cents upon the results for the month and period. The divisional recapitulation shows the results for each division, and may be used for their comparison. With a personal knowledge of the conditions existing at the time it can be told whether the increase in any class is likely to be permanent or not, and shows which engines are expensive or cheap to maintain. By reference to the class sheets the individual engines causing any variation can be located and the reason ascertained.

The recapitulation shows the total cost per mile and per unit mile for all the engines shopped during the month and period, and it evidently gives a figure that is independent of the amount of shopping done each month, of the mileage run each month and of any variation in the condition of power, all of which conditions affect the figure usually derived by dividing the cost of shop repairs by the miles run during the month. The latter figure is very similar to that which would be obtained, if in a power plant producing a variable number of kilowatt hours each month with a large storage capacity for coal, the cost per k.w. hour were arrived at by dividing the coal purchased each month by the k.w. hours produced. If one month 1,000 tons of coal were purchased and the next month 500 and the k.w. hours were the same, there would be a tremendous difference in the cost. If 10,000 tons were on hand, the purchases each month could be arranged to show a low cost for a considerable time, but the results obtained would in reality be no better. Just such a condition exists in locomotive operation, the k.w. hours corre-

STATEMENT IV. (PART 2.)

INDIVIDUAL RECORD OF COST OF LOCOMOTIVE REPAIRS.

RATE PER MILE RUNNING, 1.6; SHOP, 2.0. TOTAL, 3.6. GROUP B 2.

	No. 1 Machinery Repairs.							Running Repairs.			Shop Repairs.				All Repairs.		
			Labor.		Material.												
Station.	Tubes.	Firebox.	Boiler Work.	Other Work.	Boiler Work.	Other Work.	Total.	Per Mile.	Excess.	Decrease.	Per Mile Inter	Per Mile Final.	Excess.	Decrease.	Per Mile.	Excess.	Decrease
Angus.	1	2	205.41	720.30	65.24	185.78	1,176.73	1.04	...	417.95	2.45	1.56	592.52	......	3.83	174.57	......
Tor. Jct	1	..	187.30	841.07	49.26	442.91	1,520.54	1.13	...	255.29	....	2.37	301.73	......	3.66	46.44	......
Angus.	..	..	199.19	985.81	74.15	320.44	1,579.59	1.08	...	415.65	....	1.96	......	29.47	....	......	445.12

spond to the miles run, the cost of coal to the cost of shop repairs and the condition of the power represents a very large stock and it can be drawn on to quite an extent for a time, but no real saving is obtained by doing so; in fact, the reverse is the case. In tne system of accounts outlined above, each lot of k.w. hours is compared to the cost of coal required to produce it; in other words, the cost per k.w. hour of the coal used is shown, whereas on the other system the cost per k.w. hour of the coal bought is the figure obtained.

These shop repair statements in conjunction with that for running repairs make a very complete and in reality a simple and easily used analysis of the cost of repairs. Another statement may also be compiled to advantage to connect the running repairs and shop repairs on each individual engine; and while rather lengthy it is easily made up from the information previously obtained. While the running and shop repairs have been obtained separately, it would not be possible to determine whether an engine that was light on running repairs was heavy on shop and vice versa; nor the effect of making specific and intermediate repairs on the cost of the general overhauling. Statement IV., which is self-explanatory, connects these various costs together for each engine receiving general repairs and is of considerable value as a matter of record.

The cost per mile, as shown in these various statements, will not even on the average compare with that obtained in the usual way, except on the one condition that for a considerable period no power is bought or scrapped and the condition is maintained the same, but it will in general be greater. If any engine is scrapped it is evident that the mileage should be credited to the mileage shopped without any corresponding cost for shop repairs, and this may be done if desired, but it reduces the value of the comparison showing what the engines shopped are actually costing per mile. The purchase of new power introduces a complication that cannot be allowed for accurately, but it approximately reduces the cost of shop repairs on the mileage run basis in the ratio of the number of engines bought to the total. The value of these statements is not, however, to tell what the cost per mile will be on the general accounts, but to tell the department itself what it is doing and explain the reasons for its results. They can mislead but slightly, as if a light repair is called a general it shows better results for that month, but just as soon as that engine needs its general repairs, the error is rectified, and in fact if kept accurately these accounts are very positive, and they occasionally show results that are not in the least expected. While they may appear complicated, they are exceedingly easy for a busy man to follow, as the important figures stand out clearly and are few in number, and the number of engines receiving shop repairs each month even on a large road is not sufficient to become confusing and it is only those that are individually followed. With the proper system for compiling the figures they are not expensive, one man being able to prepare the statements for 1,000 engines. The system could evidently be applied to car repairs, especially if put on a monthly in place of a mileage basis and would afford equally good results.

The advisability of introducing a system of statistical accounts for the motive power department, that have no direct connection with the general accounts of the road, may be objected to, but the fact remains that those acounts are not so compiled as to permit an accurate comparison of the results obtained or to be of any assistance in locating a source of undue expenditure. Neither do they enable a superintendent of motive power to compare the results obtained on several divisions in a rational and definite manner. This system of accounts brings out in a clear and positive form the value of mileage between shoppings as being of equal importance to the cost of an engine shopped. It reveals in its money value the loss that occurs when an engine is improperly maintained and has to be prematurely shopped. It clearly defines the various and complicated factors that together make up the total of the maintenance of locomotive account.

TEST OF ALFREE-HUBBELL VALVE GEAR.

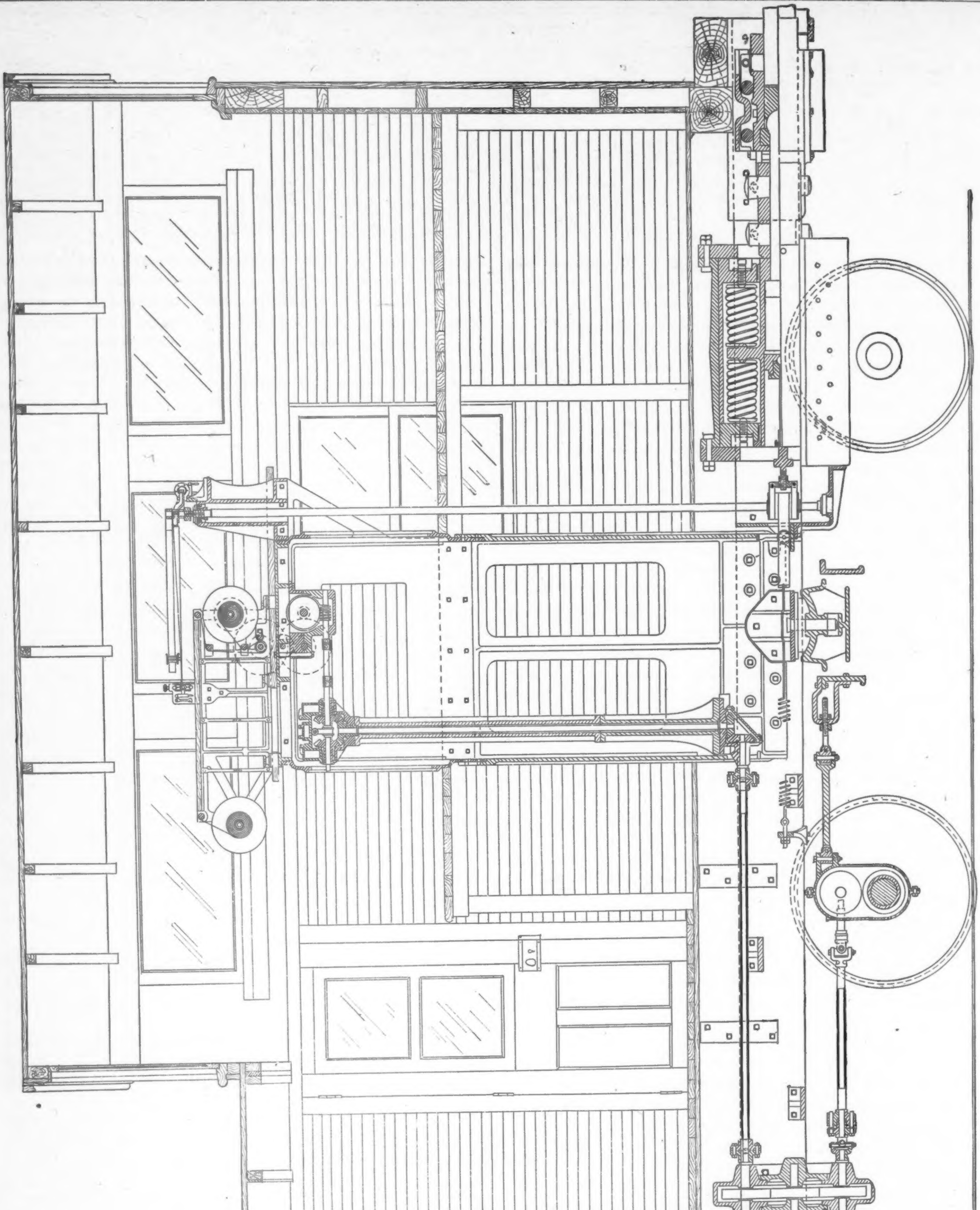
Engine No. 581 of the Central Railroad of New Jersey, which is equipped with Alfree-Hubbell valve motion and cylinders, has been compared with engine No. 582, which is similar in all respects except that it has the usual link motion and American balanced valve. The tests were made between Jersey City and Philadelphia on the same train, with the same engineer and fireman and conditions were kept as nearly alike as possible. The results of a round trip with each engine, which represented normal conditions, are given in the accompanying table. These tests show a saving in coal of 10 per cent. and a saving in water of 10.45 per cent. In this case engine No. 582 had a nozzle ⅛ in. larger than that of the Alfree-Hubbell engine. Other tests showed a saving in coal of 16.1 per cent. and in water of 15.92 per cent. in favor of the Alfree-Hubbell engine, these figures being deduced from the pounds of water and coal per ton mile. The report states that this saving, however, is larger than would actually occur under normal conditions.

In the tests showing the larger figures of saving the results were involved with the use of steam heat for the train. The results given in the table are believed to represent normal conditions.

We are indebted to Mr. William McIntosh, superintendent of motive power, and Mr. B. P. Flory, mechanical engineer, of the Central Railroad of New Jersey, for this information.

	5-in. Nozzle. Engine 581.	5⅛-in. Nozzle. Engine 582.
Weight of train, tons	173.35	172.9
Weight of coal, pounds	7,706	8,502
Weight of water, pounds	65,381	72,826
Pounds coal per ton mile	.2455	.273
Pounds water per ton mile	2.087	2.3306
Average steam pressure	189.8	181.8
Number of minutes blow-off	107	51.0
Average speed, M. P. H.	45.97	47.01
Saving coal, per cent	10.00	....
Saving water, per cent	10.45	....

A 5,000-HORSE-POWER GAS ENGINE PLANT.—The California Gas & Electric Corporation has adopted gas engines, three in number, of 5,333 h.p. each, for the new plant for the operation of the street railway system of San Francisco. Oil gas will be used, and the engines will be direct connected to 4,000 k.w. 25-cycle alternators built by the Crocker-Wheeler Company. This involves the largest gas engines ever constructed in the United States. The low cost of crude petroleum in California determined the selection in favor of a gas engine plant.

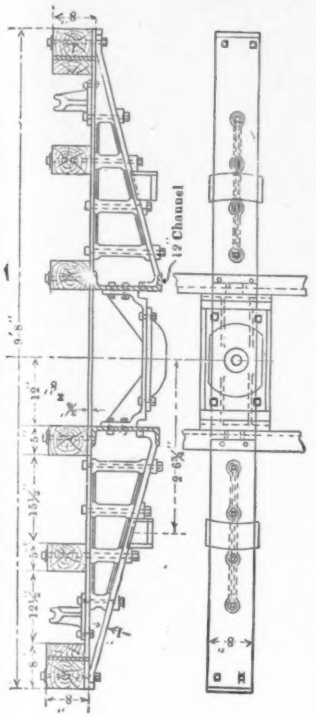


DYNAMOMETER CAR, NEW YORK CENTRAL LINES—SHOWING DRAFT AND RECORDING MECHANISM.

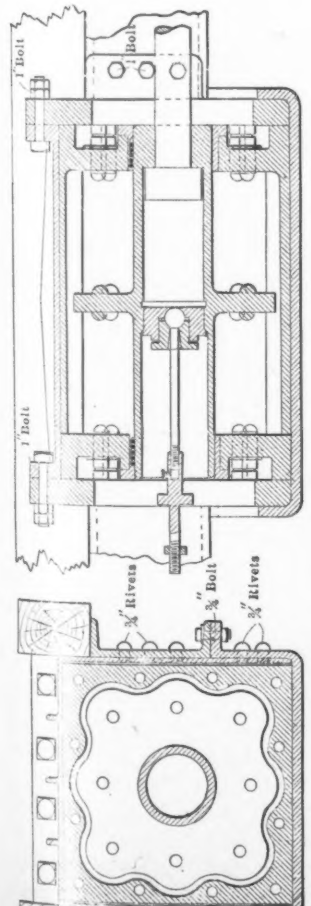
DYNAMOMETER CAR.

New York Central Lines.

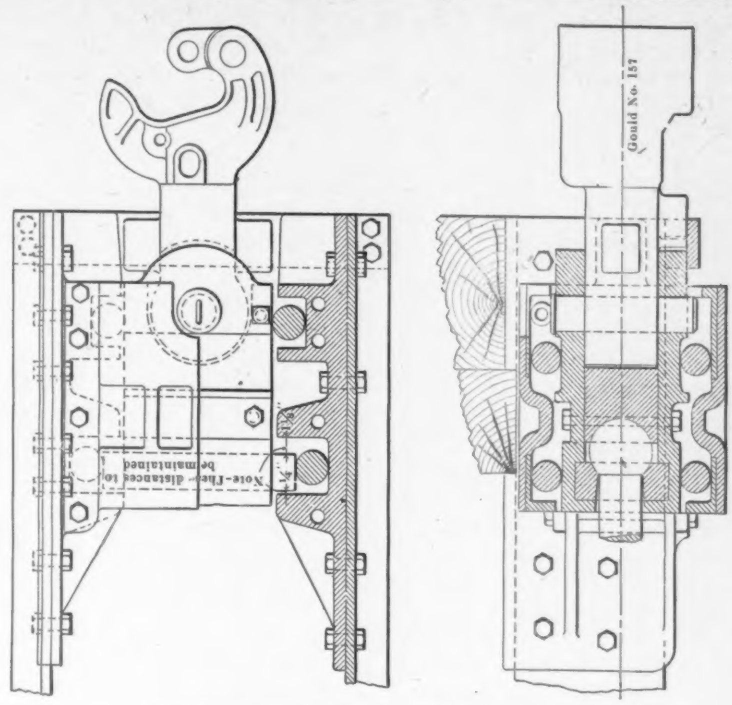
The new dynamometer car, which is illustrated from drawings received from Mr. F. M. Whyte, general mechanical engineer of the New York Central lines, has just gone into service. This is a new car built specially for the purpose. The design of this car itself was influenced by a desire to place the recording mechanism in the cupola in order to place the operators in a position of advantage in recording mile posts and other road data. For this reason the cupola is made high, and the body of the car low, so that the operators may see over the body of the main portion of the car. This car is 44 ft. long, with the dynamometer gear in one end; two sleeping-car sections, a kitchen, toilet-room, and heater in the other end, with a writing desk, work bench and recording table in the center. The platform of the cupola is 3 ft. 11 ins. above the main floor. The car has 6 wooden sills and 2 sills in the form of 12-in. channels. These are spaced 24 ins.



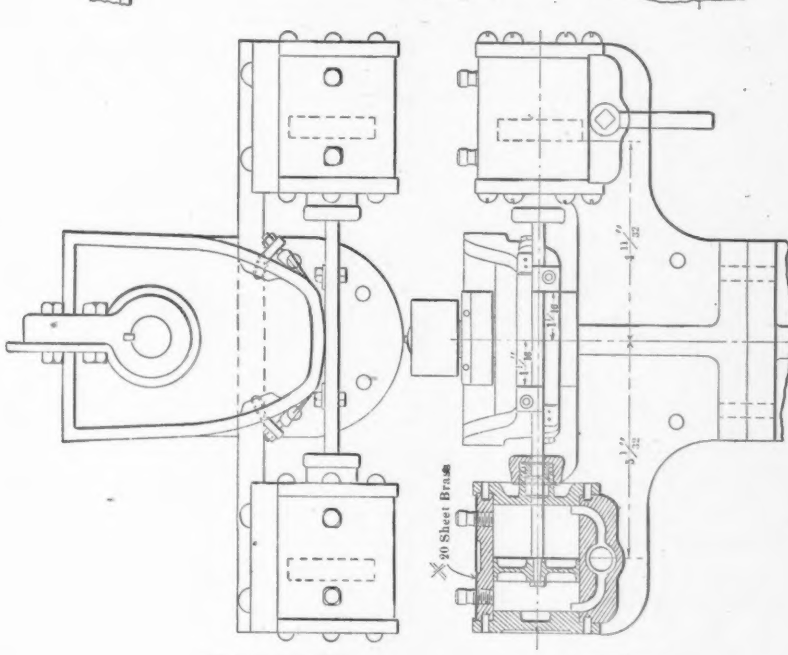
SECTION THROUGH FLOOR FRAMING AND BODY BOLSTER.



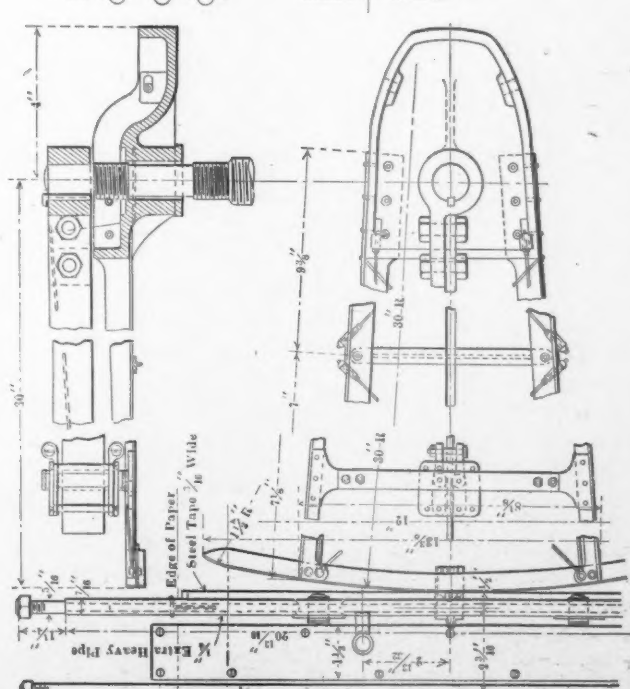
DRAFT GEAR SHOWN WITH SPRINGS OMITTED.



COUPLER ATTACHMENT.



DASH POTS FOR RECORDING ARM.



RECORDING ARM.

DYNAMOMETER CAR, NEW YORK CENTRAL LINES.

apart, in order to provide for the dynamomenter springs and extend the full length of the car. Upon these channel sills rests a frame of cast steel plates, which supports the recording table, and forms a rigid connection between the draft sills and the table. To increase the stiffness of the car, end platforms are omitted.

The general arrangement of the dynamometer and the recording mechanism is quite similar to that of the Chicago & Northwestern dynamometer car, illustrated in this journal in June, 1900, page 172. The construction is modified because of a higher recording table, but the paper-driving mechanism, the dynamometer itself and the recording devices are similar. Springs, 16 in number, are arranged in two sets, with a follower between them. The casing gives these springs an initial compression. The free height of the springs is 10¾ ins. for one side, and 11¼ ins. for the other side; one set gives 50,000 lbs. capacity and the other set 100,000 lbs. The purpose of the initial compression in the springs is to cause the discrepancies between the deflections of increasing and decreasing loads to neutralize each other. The initial load is sufficient to guard against either side becoming entirely unloaded in the maximum draw bar pull. The recording movement is taken from the central follower, to which the coupler is attached, the pull and thrust of the draw bar being transmitted to the draft sills through the casting containing the springs. The vertical shaft connects the motion of the draw bar to the recording arm, which connects with a pencil arm by means of flexible steel bands. The pencil arm extended upon the opposite side of its pivot connects with a pair of dash pots, communicating motion to the arm by means of flexible steel bands.

The paper-driving mechanism is clearly shown in the engraving, which also illustrates the clutch for reversing the motion as the direction of the movement of the car is changed, thus always keeping the paper moving in the same direction. The pencil arm moves back to the datum position under the influence of the long steel spring, which also keeps the slack out of the motion. The vertical shaft leading to the pencil arm is supported upon ball bearings. The recording mechanism is equipped with an automatic integrator, and pens actuated by electricity are provided for the time, mile post, indicator card and other data.

The draw bar is carried on a special yoke, with roller bearings to carry its weight and take the side thrusts. This involves the use of horizontal and vertical rollers. The trucks have four wheels, each with equalizers; the wheel base being 8 ft.; the wheels being 35 ins. in diameter.

The speeds of the paper, as determined by the gearing and the driving mechanism, are such as to record 1-16, ⅛, ¼, ½ and 1 mile per ft. on paper.

COMMON STANDARD LOCOMOTIVES.

HARRIMAN LINES.

Last month comparative dimensions and weights of the four standard locomotives for the Harriman Lines were presented with a brief statement of some of the parts which are made standard to all locomotives. Some of the details may now be recorded.

All classes of locomotives have the same eccentric strap. This was made in cast steel with a light webb section, as indicated in the sectional drawing. The section and side view illustrates the loose ring which is made in three parts and of brass. This ring is not secured either to the eccentric or to the strap and may revolve freely. It is provided with six ⅜-in. oil holes to carry lubricant from the outside to the inside. The oil cups are cast with the strap and two cups are provided at the lower side of the strap, having removable plugs in order to clean them. This standard permits of the use of one pattern of eccentric strap for passenger, freight and switching locomotives.

Eccentric.—One eccentric design fits all classes of engines. The eccentric throw is 5 ins., as shown in the drawing, the forward motion eccentric has a 6-in. bearing on the axle, whereas the backward motion has but 4¼ ins. This was done in order to avoid too great an offset in the eccentric rods and this arrangement makes it possible to use two eccentric patterns for all new locomotives on the system. The eccentrics are secured with key and set screws, the two halves of the backward motion eccentric being secured together by studs and those of the forward motion secured by studs and also by bolts on the projecting hubs.

Driving Boxes.—These are all cast steel and are of two sizes, one being 9 x 12 ins., common to all engines, and the other 10 x 12 ins., which is used for the main boxes of the consolidation and Pacific types. As the designs are in all respects similar, except as modified for the two journal diameters mentioned, the larger one only is shown. These boxes have substantial brasses 2¼ ins. thick at the crown and with four ½-in. oil holes from the oil pocket leading to the cavity at the center. Two strips of babbitt 2 ins. wide are let into the brass as indicated. The entire outer face of the outside of the box is babbitted in a dovetail groove. The cellar is of cast iron and is provided with a removable plate on the inside for convenience in packing.

Cross Head.—One cross head fits all engines. The body is of cast steel and the removable shoes are of bronze. The shoe area is 5½ ins. wide by 24 ins. long. The engraving also shows the cross head pin and piston rod end. This cross head is light and convenient to maintain. Oil cups are cast in the lower shoes and attached through the body of the cross head for the upper shoes. Each shoe is secured to the body by 4 bolts.

Wheels.—All the driving wheel centers are of cast steel with cavities for counterbalances of lead, which are figured by the Master Mechanics' Association rule. All of the driving wheels of the standard engines are shown, and weights, together with the counterbalance weights, are presented in the accompanying table. It will be noticed that in order to get approximately the same cylinder spread on all of these engines, viz., 89 ins. for the Pacific and Consolidation types; 88 ins. for the Atlantic type, and 87 ins. for the switcher, the length of the hubs of the driving wheels differ. It will be noted that in all cases the estimated weight of each crank pin hub is given in the table. The tires of the Pacific and Atlantic type are shrunk on and bear against a shoulder on the outside of the tire. The drawings show the distance of the center of gravity of the counter balance of each wheel from the center of the axle.

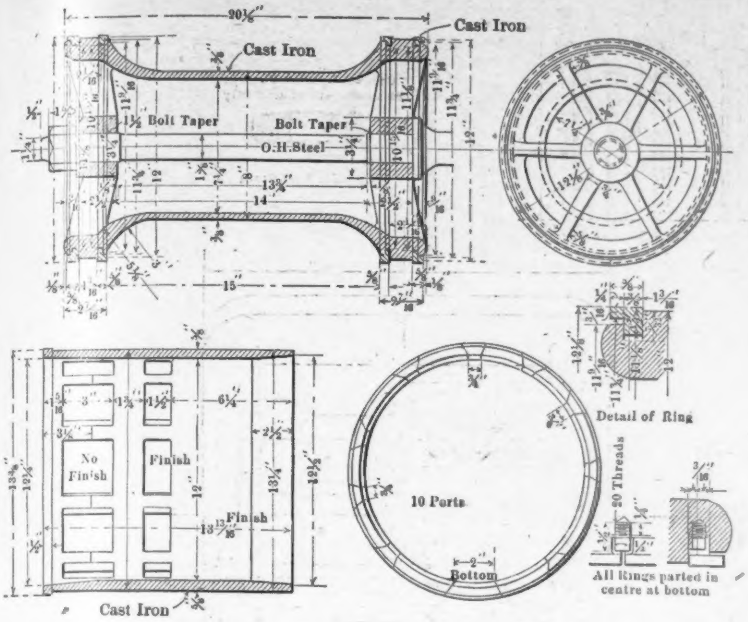
Truck Wheels.—All truck wheels have cast iron centers and steel tires made by the Standard Steel Works. For the Atlantic and Pacific types the truck wheels are 33½ ins. in diameter. The normal weights are as follows:

Tire when finished	480 lbs.
Tire when rough	540 lbs.
Center when finished	435 lbs.
Center when rough	475 lbs.
Two retaining rings	55 lbs.
Bolts and nuts	10 lbs.
Finished wheel	980 lbs.

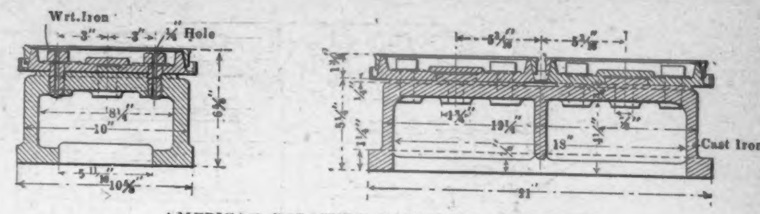
The truck wheels of the Consolidation types are 30½ ins. in diameter. The normal weights are as follows:

Tire when finished	434 lbs.
Tire when rough	490 lbs.
Center when finished	392 lbs.
Center when rough	445 lbs.
Two retaining rings	48 lbs.
Bolts and nuts	10 lbs.
Finished wheel	884 lbs.

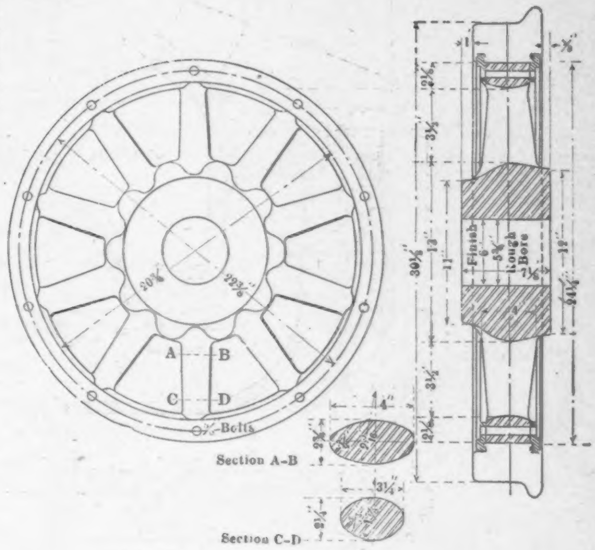
Valves.—The valves of the switcher are of the flat type with American balance, using two rings, all the rest are of the piston type, 12 ins. in diameter, one valve serving for all the road engines. This valve is of cast iron with 2 L-shaped rings at each end. The valve rods are all 2 ins. in diameter and vary in length only. The piston valves have internal admission, the motion being indirect and the eccentric rods are crossed. The engraving of the valve also illustrates the bushing and ports. The valve stems are not extended. Two pis-



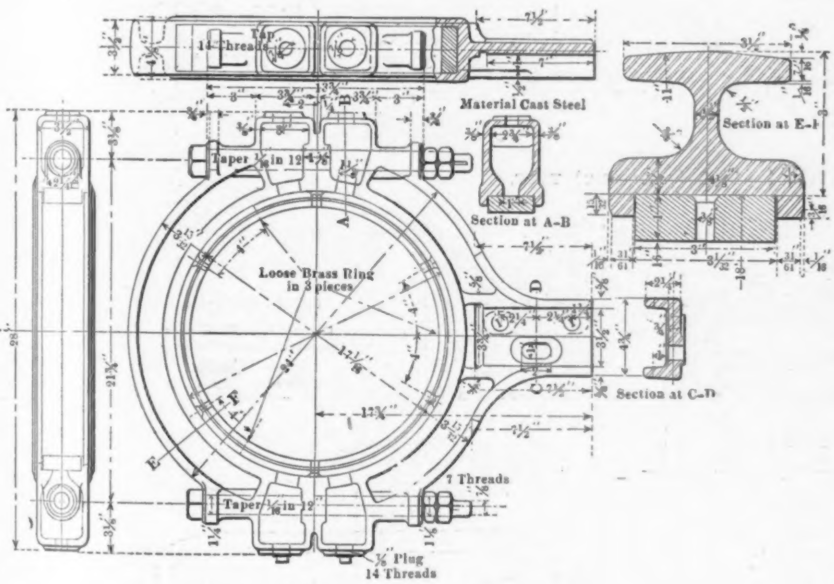
PISTON VALVE FOR ROAD ENGINES.



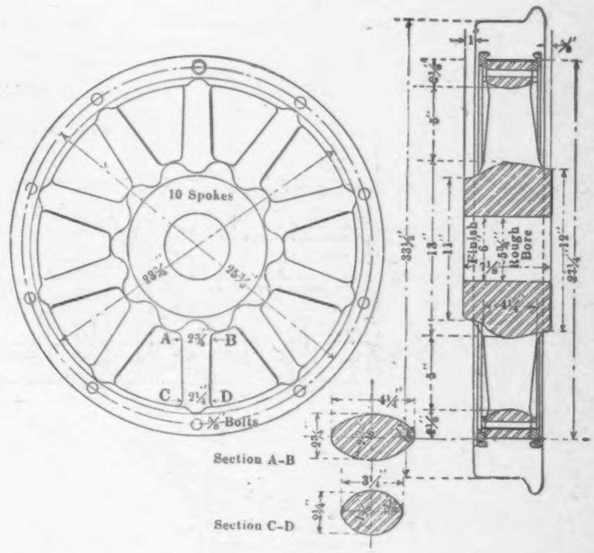
AMERICAN BALANCED VALVE FOR SWITCHERS.



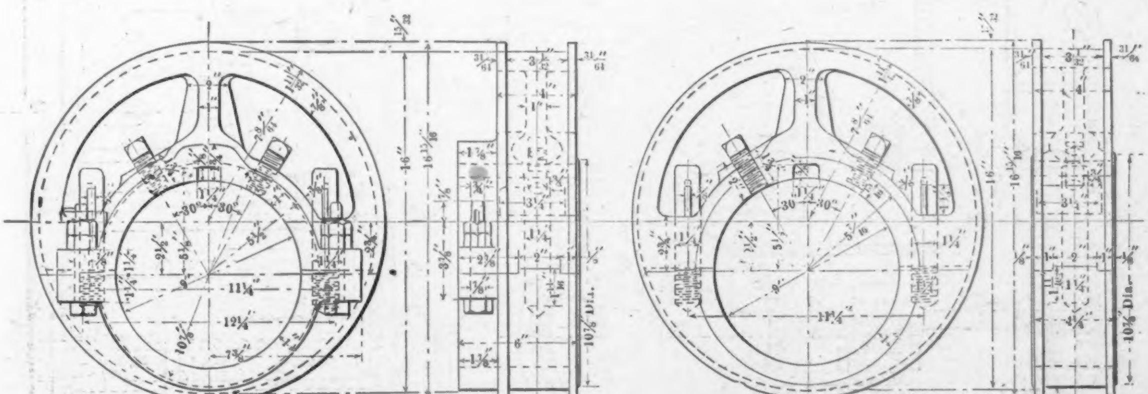
TRUCK WHEEL, CONSOLIDATION TYPE.



ECCENTRIC STRAP, ALL ENGINES.

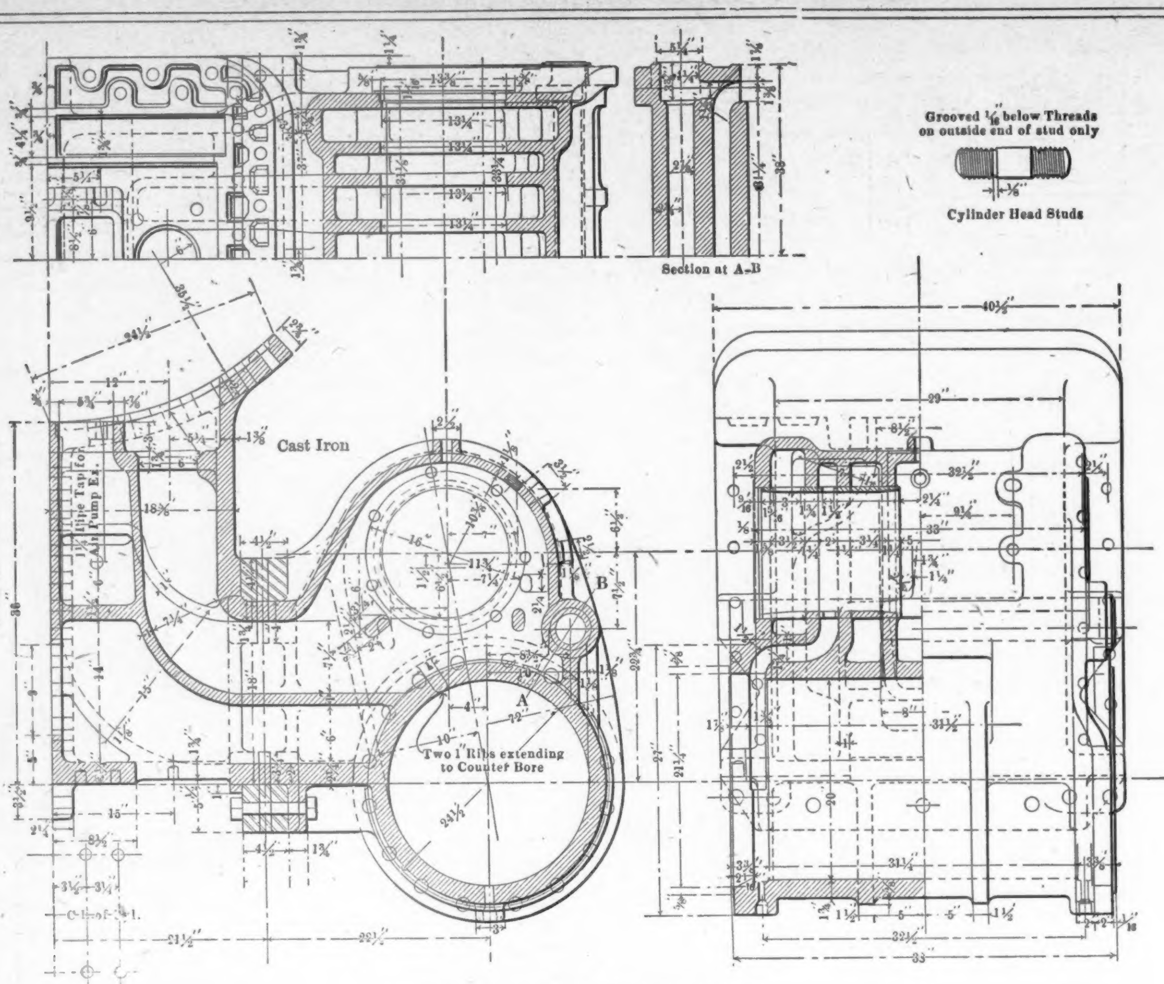


TRUCK WHEEL, PASSENGER ENGINES.

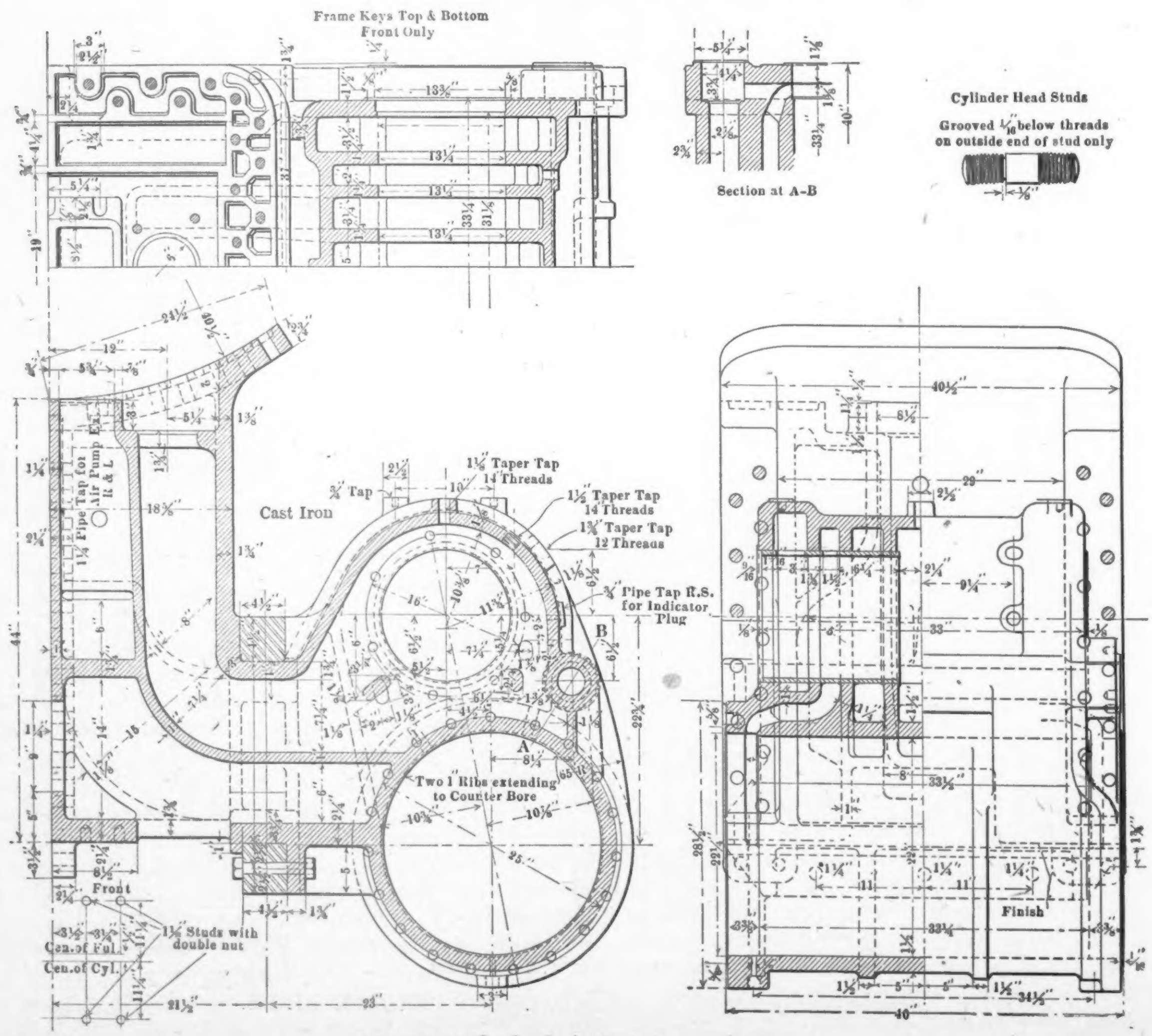


ECCENTRICS FOR ALL ENGINES.

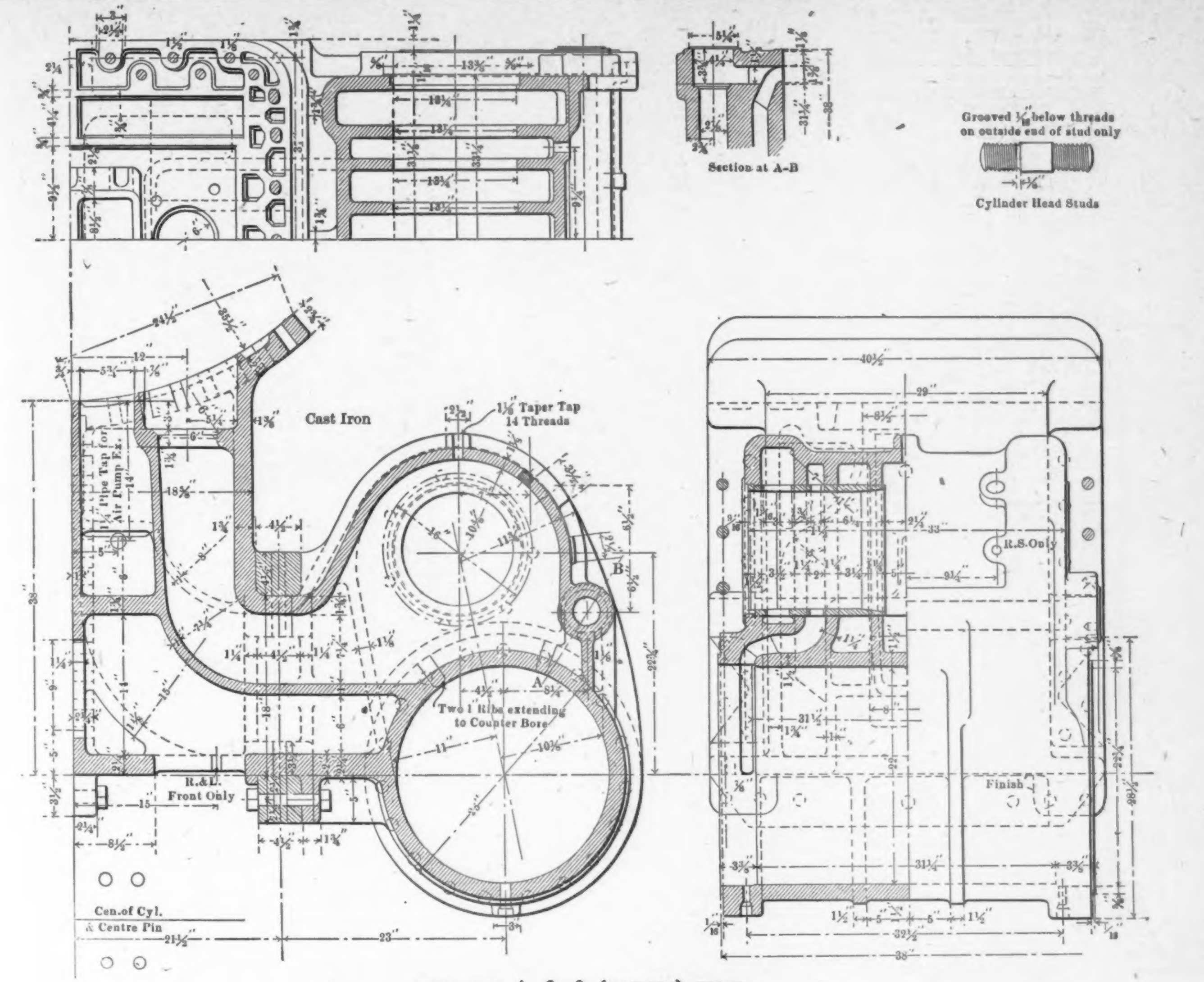
COMMON LOCOMOTIVE STANDARDS—HARRIMAN LINES.



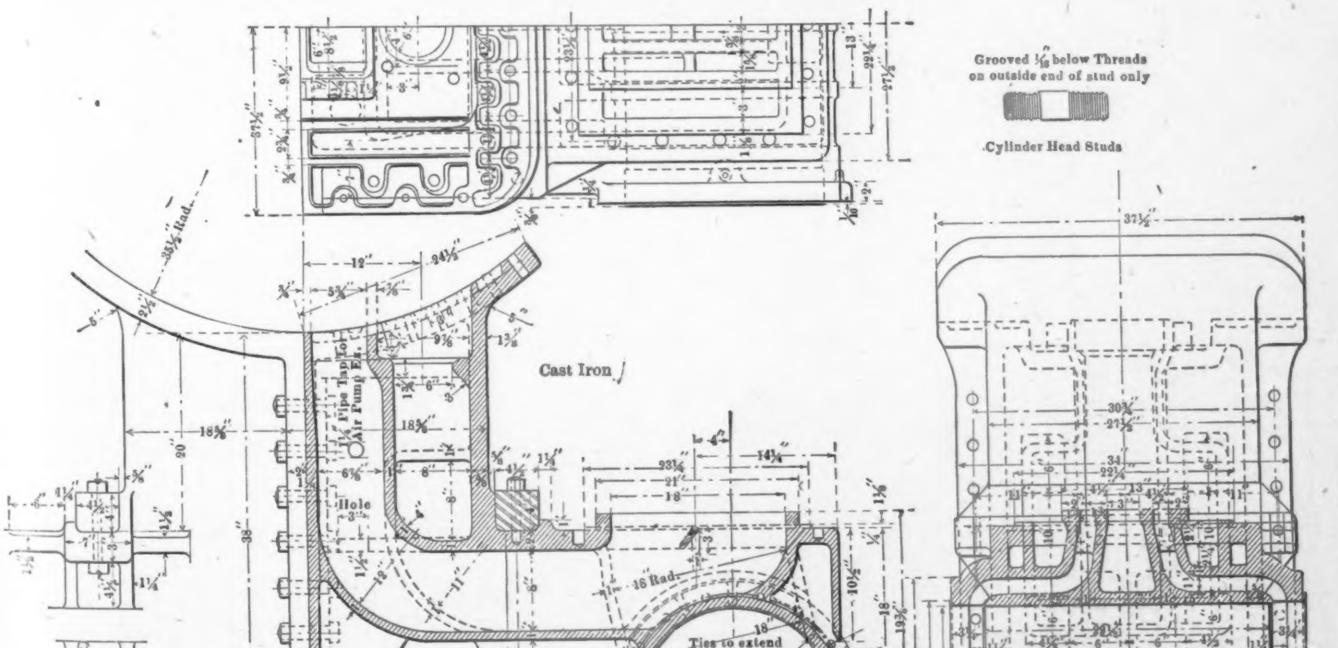
CYLINDERS, 4—4—2 (ATLANTIC) TYPE.



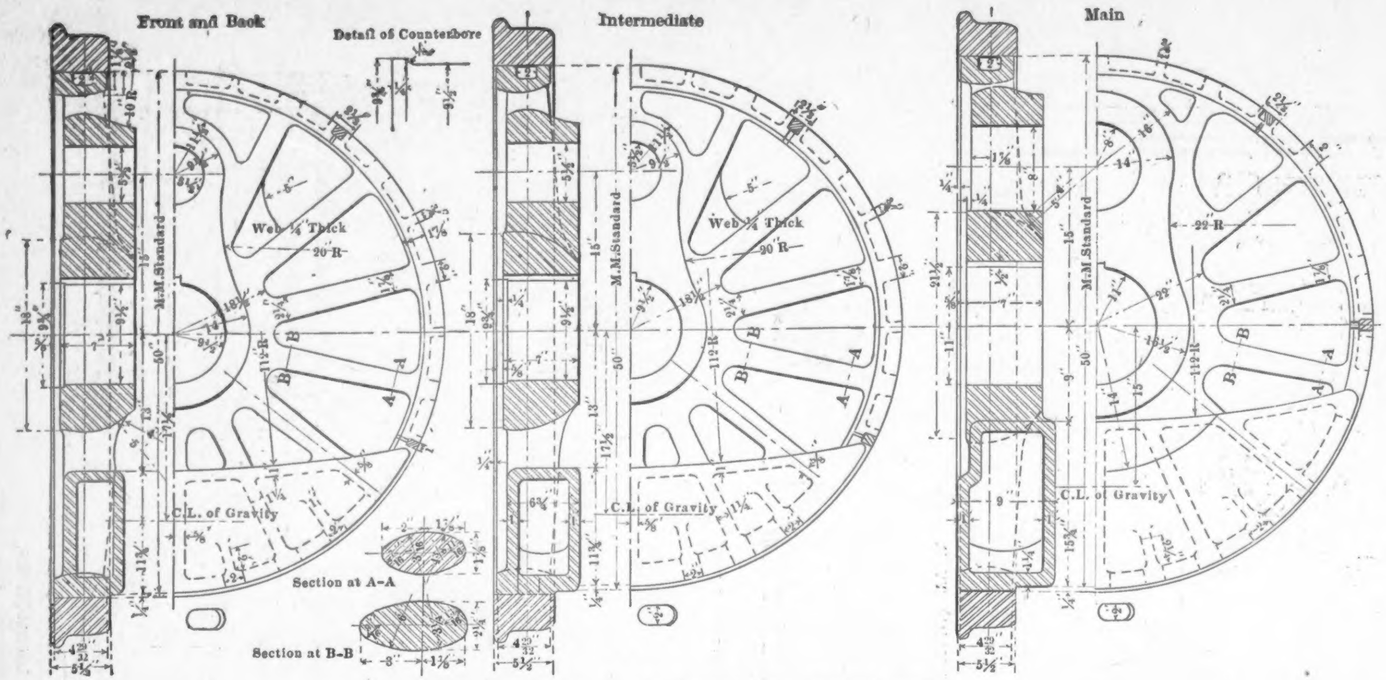
CYLINDERS, 2—8—0 (CONSOLIDATION) TYPE.



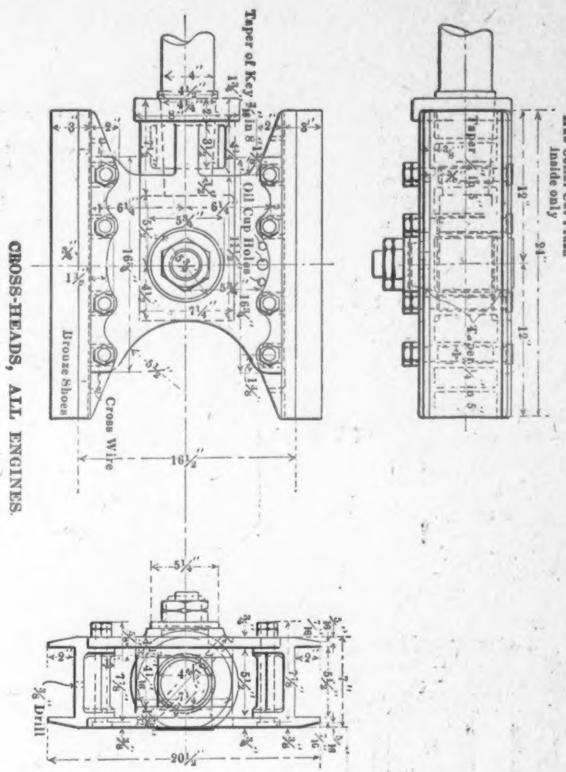
CYLINDERS 4—6—2 (PACIFIC) TYPE.



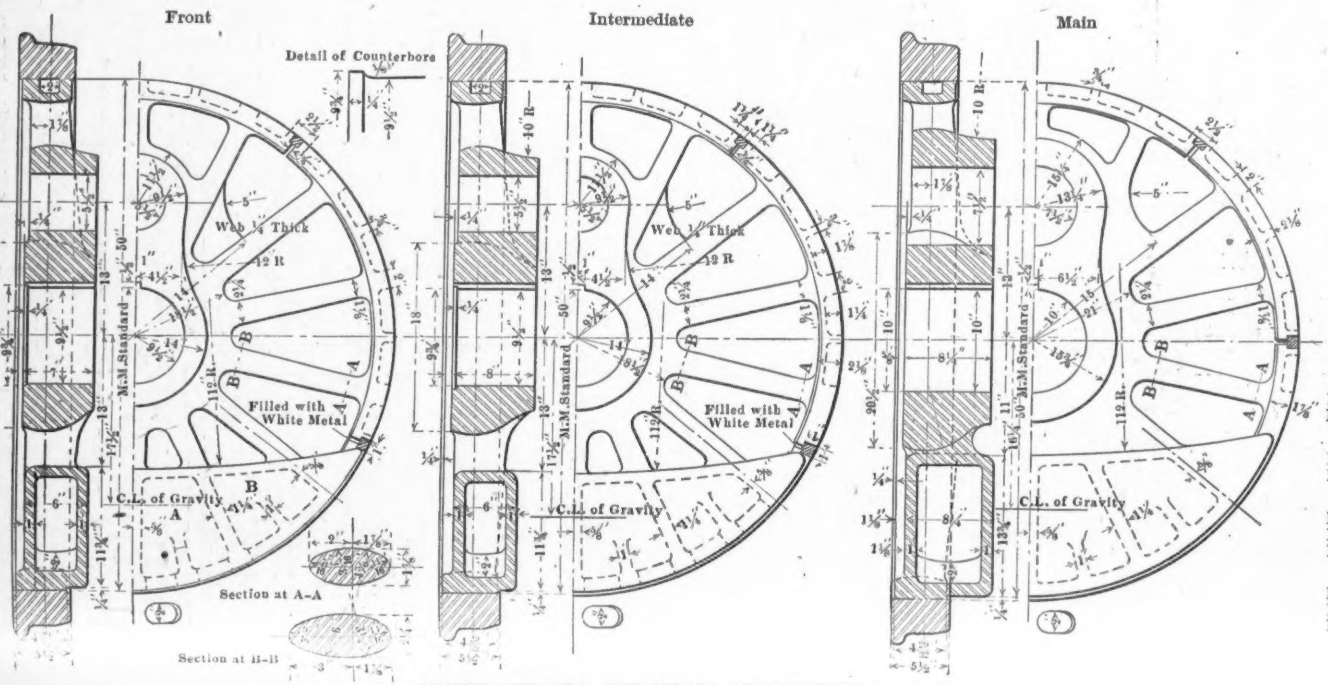
CYLINDERS, SWITCHING LOCOMOTIVES.



DRIVING WHEELS, 2—8—0 (CONSOLIDATION) TYPE.



CROSS-HEADS, ALL ENGINES.

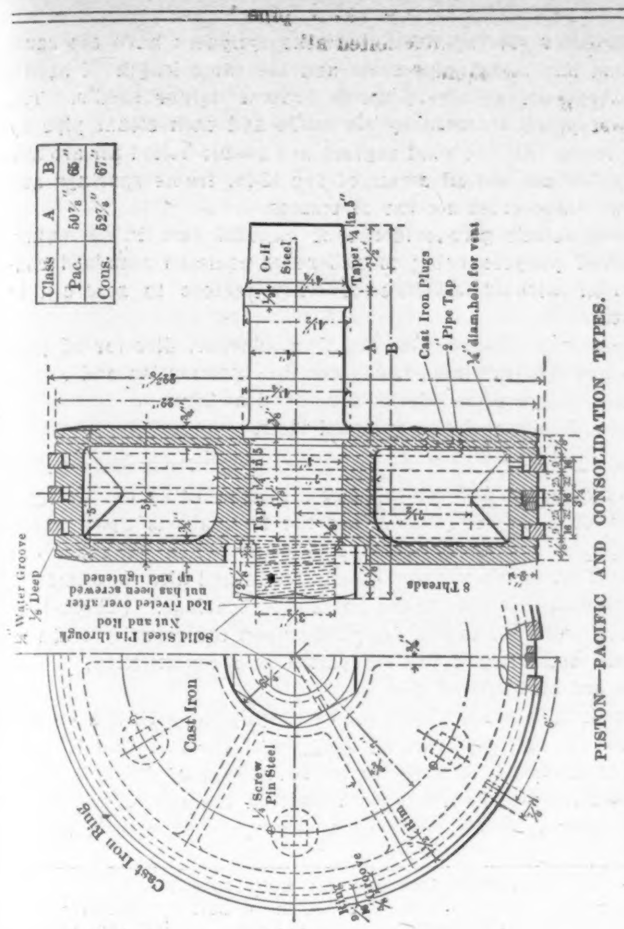


DRIVING WHEELS, SWITCHING LOCOMOTIVES.

COMMON STANDARD LOCOMOTIVES—HARRIMAN LINES.

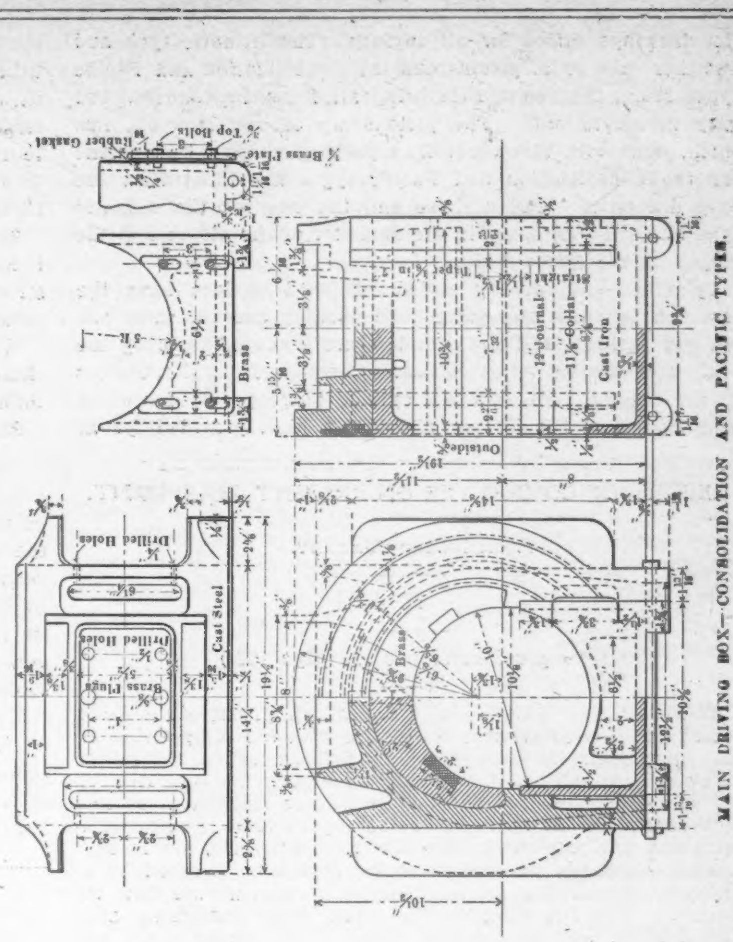
NORMAL WEIGHTS OF DRIVING WHEELS.

	Centre Only. Rough	Centre Only. Finished	Tire Only. Rough	Tire Only. Finished	Estimated Weight of Crank Pin Hub.	Lead Filling	Total Weight of Completed Balance	Finished Wheel with Balance
ATLANTIC TYPE.								
Main	2840	2500	1480	1419	180	390	658	4366
Front	2800	2450	1480	1419	139	128	332	4059
PACIFIC TYPE.								
F. & B.	2430	2191	1400	1339	106	53	326	3620
Main	2710	2321	1400	1339	152	456	840	4210
CONSOLIDATION.								
F. & B.	1895	1487	1015	998	140	270	509	2755
Inter.	1960	1509	1015	998	140	348	635	2805
Main	2250	1825	1015	998	235	825	1392	3648
SWITCHER.								
Front	1868	1468	1015	998	102	174	425	2640
Inter.	1894	1494	1015	998	118	315	566	2807
Main	2217	1767	1015	998	190	625	1044	3390

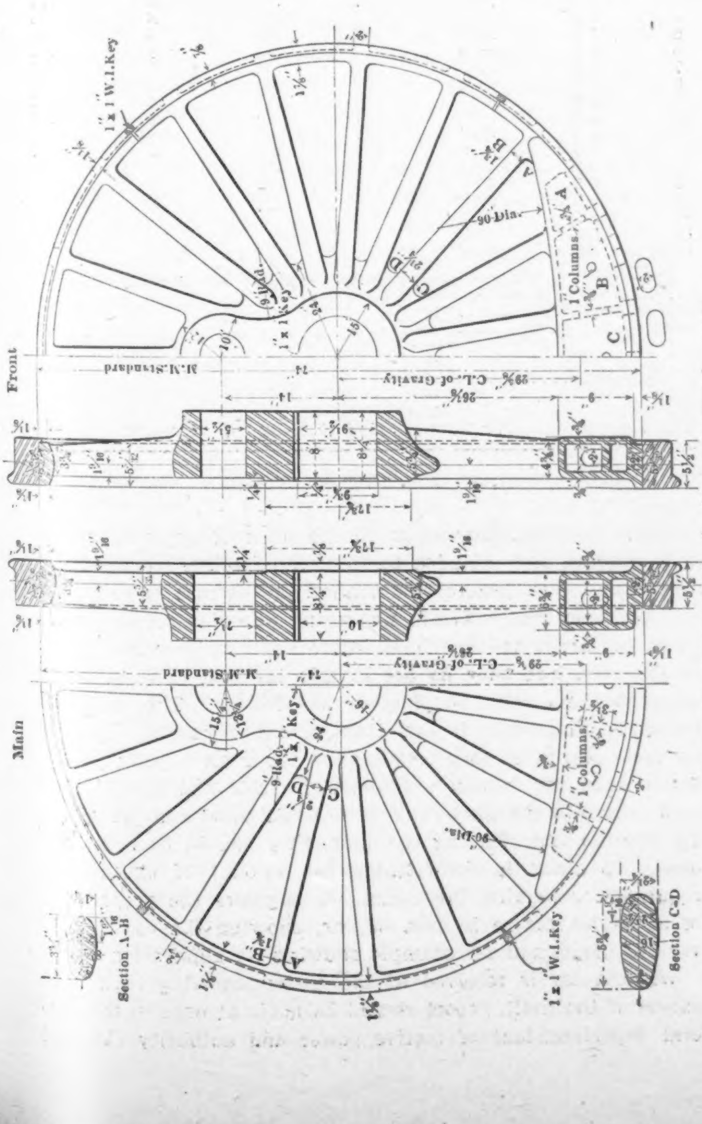


Class	A	B
Pac.	50 7/8"	65"
Cons.	52 7/8"	67"

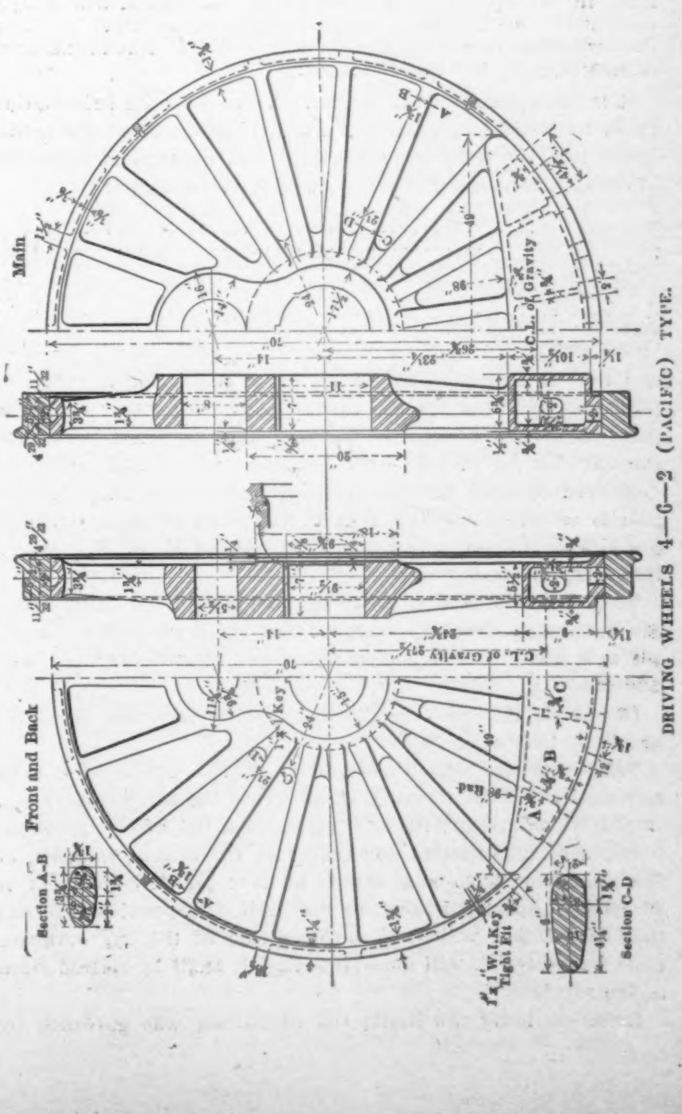
PISTON—PACIFIC AND CONSOLIDATION TYPES.



MAIN DRIVING BOX—CONSOLIDATION AND PACIFIC TYPES.



DRIVING WHEELS, 4—4—2 (ATLANTIC) TYPE.



DRIVING WHEELS 4—6—2 (PACIFIC) TYPE.

ton drawings suffice for all engines. The Atlantic type and switcher take 20-in. pistons and the Consolidation and Pacific types 22-in., the piston rods being all 4 ins. in diameter and vary in length only. The pistons are of cast iron 5¼ ins. thick, each with three cast iron packing rings. The pistons for the Consolidation and Pacific types are illustrated, the only difference between these and the one for the Atlantic type and switcher being in the diameter of the piston and the length of the piston rod.

Cylinders.—As already stated, all road engines have the same piston valve and valve stem packing and the same piston rod packing, and the cylinders are arranged to bring the centers of the valves at the same distance from the centers of the frames. All of these cylinders are provided with a modification of the Sheedy circulating pipe, provided for in the cylinder casting itself. All the cylinders have the same exhaust and steam pipe seats and the same length of saddle fit except the switchers which have a lighter saddle. The exhaust pipes are held by six studs and each steam pipe by four studs. All the road engines are double bolted all around. The cylinders are all arranged for 43-in. frame spacings and for the same cross section of frames.

These details give evidence of unusual care in designing, the chief purpose being to adhere to common standard construction without sacrifice of other factors to secure this result.

We are indebted to Mr. W. V. S. Thorne, director of purchases of the Harriman Lines, for this information and to the Baldwin Locomotive Works for the drawings.

Other details will be presented later.

REPORT OF COMMITTEE ON FREIGHT EQUIPMENT.

ROCK ISLAND COMPANY.

II.

(*For previous article see page* 153.)

EDITOR'S NOTE.—This study of the car equipment of the Rock Island and 'Frisco systems deals first with the composition of the equipment, its age, cost and present value. This is followed by a statement in detail concerning the condition of the equipment, the recommendations as to retirement or improvement. In this portion of the report various equipment parts and devices, which have given good service, are recommended. A large proportion of the report is occupied by a statement concerning all the various groups of cars now in service. The following section deals with numbering and classification, and the report closes with recommended designs for new equipment. The size of the report and the large variety of different classes of cars forming the equipment of a combination of roads, together with the very large investment in car equipment are impressive features of this unique document. No argument could possibly be stronger to show the necessity from a commercial standpoint of standardization. Abstracts from the report follow:

It is the opinion of the committee, based on the information given in these diagrams, and actual observation of the equipment, that the limit of safe, useful and economical operation of wooden cars is reached at the ages given below:

Box cars	18 years
Furniture cars	18 years
Refrigerator cars	12 years
Fruit cars	14 years
Stock cars	14 years
Coal cars	14 years
Flat cars	14 years
Ballast cars	12 years

and that an annual depreciation, based on the above terms of years and allowing for the value of the scrap material in the cars, should be charged off, so that when the limit is reached the car can be retired from revenue service and either be destroyed or used in yard or work train srvice only. Attention is called to the fact that the average of these limits is practically the same as established by the M. C. B. Association, viz., 16 years.

To find the value of a car at any age within the limits above given, subtract from the original cost the scrap value. Multiply this result by the percentage shown opposite the age, and add the scrap value.

In calculating the value of the caboose cars, the age limit has been take at 25 years.

Tables give the number of cars in service October 1st, 1904, arranged in series, showing in each case the car numbers and initials, length, capacity and age, also a list of the principal features of construction, together with the recommendation of the committee as to what should be done for its betterment, if 60,000 lbs. capacity or over, or the limit of expenditure, if less than 60,000 lbs., which, if the condition of the car indicates must be exceeded, will determine that it shall be retired from active service.

In determining the limits the committee was governed by not only the age and condition of the cars, but by the strength of the body bolsters, which are the foundations upon which the superstructure is carried, and which when weak are the cause of excessive wear of wheel flanges and also derailments, by excessive friction on the truck side bearings. (These limits vary from $10 to $80, depending upon the capacity and the general character of the equipment and construction. The tables are omitted.—EDITOR.)

The limit is made higher for cars equipped with the American continuous draft rigging, because of the fact that if it is thought advisable to apply an improved type of draft, it must of necessity be applied to both ends of the car at the same time, whereas in the case of a car equipped with a single spring draft, the new type may be applied to one end at a time.

VALUATION OF CAR EQUIPMENT.

	Box and Furniture.		Fruit, Stock, Coal and Flat.		Refrigerator and Ballast.	
Years.	Rate.	Percentage.	Rate.	Percentage.	Rate.	Percentage.
1	5.5	.945	7	.93	8	.92
2	5.5	.890	7	.86	8	.84
3	5.5	.835	7	.79	8	.76
4	5.5	.780	7	.72	8	.68
5	5.5	.725	7	.65	8	.60
6	5.5	.670	7	.58	8	.52
7	5.5	.615	7	.51	8	.44
8	5.5	.560	7	.44	8	.36
9	5.5	.505	7	.37	8	.28
10	5.5	.450	7	.30	8	.20
11	5.5	.395	7	.23	8	.12
12	5.5	.340	7	.16	8	.04
13	5.5	.285	7	.09		
14	5.5	.230	7	.02		
15	5.5	.175				
16	5.5	.120				
17	5.5	.065				
18	5.5	.010				

Example: A box car costing originally $660 has a scrap value of $110. What is it worth when 16 years old?

Original cost	$660
Deduct scrap value......	110
	$550
Percentage	.12
	66.00
Add scrap value......	110.00

$176.00 value at 16 years.

These recommendations as to the limit of expenditure are only general, and intended to show the relative worth of the cars, and are subject to modification in the case of such cars as have been rebuilt within five years, upon inspection as outlined hereafter, and are intended to apply only to the bodies of the cars, and they do not include the cost of running repairs to the trucks, couplers or air-brakes. The intent in recommending limits is that these amounts may be expended on such cars when they come to the shops for repairs after a given date, for instance, January 1, 1905, and should they again come to the shop for repairs to an equal amount within six months after leaving the shop, they should be retired at once. To assist in determining the amount of expenditure required for repairs, the committee suggests the preparation of schedules for each class of car, showing the cost of the various parts, and an example showing its application.

When a car is received at the shops requiring repairs in excess of the limit, report should be made at once to the general superintendent of motive power and authority obtained

for its retirement, and in recommending a car for retirement the following points should be given consideration:

First—The design, capacity and age.

Second—The condition of the longitudinal sills, bolsters, draft rigging and trucks.

Third—Its availability for some other class of service, for instance, by converting a stock car into a coke car, or a gondola car into a flat car. In each case recommended for retirement careful inspection should be made by some competent person detailed by the general superintendent of motive power to determine the action to be taken, and the decision reached should be immediately noted in the historical record.

The committee, while recommending the maintenance of wooden cars of 60,000 lbs. and 80,000 lbs. capacity, does not recommend their perpetuation beyond the age limit mentioned, nor after the time when the cost of repairs exceeds 60 per cent. of their depreciated value at the time such repairs become necessary; the intent of this recommendation being that all wooden cars should be retired when they reach their limit of usefulness, and be replaced by steel frame cars, thus gradually bringing the system to a single standard for each class.

The portions of the higher capacity cars most liable to failure are found to be the body bolsters, truck bolsters, draft attachments, door fixtures, brake beams, coal car sides, the end framing, end lining and roofs of box and stock cars and the floors of open cars.

The committee recommends, in addition to the specific recommendations in the equipment list for the strengthening of such parts, that the floors of stock, coal and flat cars when renewed should be of material 2⅜ ins. thick, and the end lining of closed cars, when renewed, be made of material 1¾ ins. thick. The end framing of closed cars should be strengthened by the addition of horizontal truss rods, which in connection with the 1¾-in. end lining will reduce the liability to damage by the shifting of the load to a minimum.

It is also the opinion of the committee that one end door is sufficient for a closed car, and such cars as now have two should be changed whenever shopped for repairs.

The sides of coal cars are frequently weak by reason of the stakes being either too small in size or insufficient in number, and in such cases they should be strengthened by the application of braces and such additional stakes as may be required.

In many cases the cars are found to be equipped with excellent draft attachments, but with draft timbers insufficiently secured. In such cases anchor rods should be applied, which will reduce the strain on the vertical bolts securing the draft timbers to the sills, and eliminate damage from loose timbers.

The door fixtures now in use on the equipment are mostly of such a design as to permit the shifting of the doors, when switching, unless closed and locked. This shifting permits the doors to pound against the stops, with the result that either the hangers become loose and the door drops off, or the stops come off and the door runs off at the end of the track, and is finally either lost or damaged by being hit by passing cars, the latter being a frequent cause of derailment of trains. The fixtures recommended have been designed in such a manner as to prevent this shifting, and when the hangers are secured to the doors by bolts, the door cannot be dislodged.

Many of the bolsters (cast steel excepted) are fitted either with pressed steel or malleable iron center plates, which are too small in bearing surface to have the strength to resist the pressure of the load, and therefore fail by punching out the bottom plate, or in which the pressure per square inch due to the load causes excessive friction, and consequently excessive flange pressure on curves by reason of the inability of the truck to turn easily under the car, which, of course, is productive of excessive flange wear on wheels and rails and also derailments on curves. The committee recommends that in such cases the center plates as they fail, or are found to bind on curves, be replaced by cast steel center plates having a sufficiently large area to bring the friction within the proper limits for the material used.

(To be concluded.)

SOUTH LOUISVILLE SHOPS.

LOUISVILLE & NASHVILLE RAILROAD.

This plant occupies a tract of 55 acres, 12½ of which are under roof. While figures on capacity are usually somewhat elastic, it was intended for the complete maintenance of 450 locomotives besides the building of a small number each year. The car department was designed to repair 100 freight cars per day, for complete maintenance of 450 passenger cars, the building of 15 new freight cars per day and the building of about 25 passenger cars per year. By the extension of buildings and arrangement of departments an extension of one-third of the present size of the plant is provided for. The plans were most carefully worked out by Mr. Theodore H. Curtis, superintendent of machinery of the road, from whom the plan and descriptive information has been received.

The plan and operation of these shops centered in the use of the most modern machinery and means of handling material, as well as the equipment which comes into these shops for repairs, to the best advantage. The three principal features of the plan are:

First—A long, pointed, fish-shaped yard extending north and south, and being relatively narrow east and west.

Second—A wide, high-speed transfer table passing east and west transversely nearly across the yard group.

Third—A high-speed, stockyard, overhead travelling crane running from the north side of the transfer table, a distance of 1,000 ft., the crane having a span of 40 ft., a clearance of 15 ft. and a bridge speed of 1,000 ft. per minute.

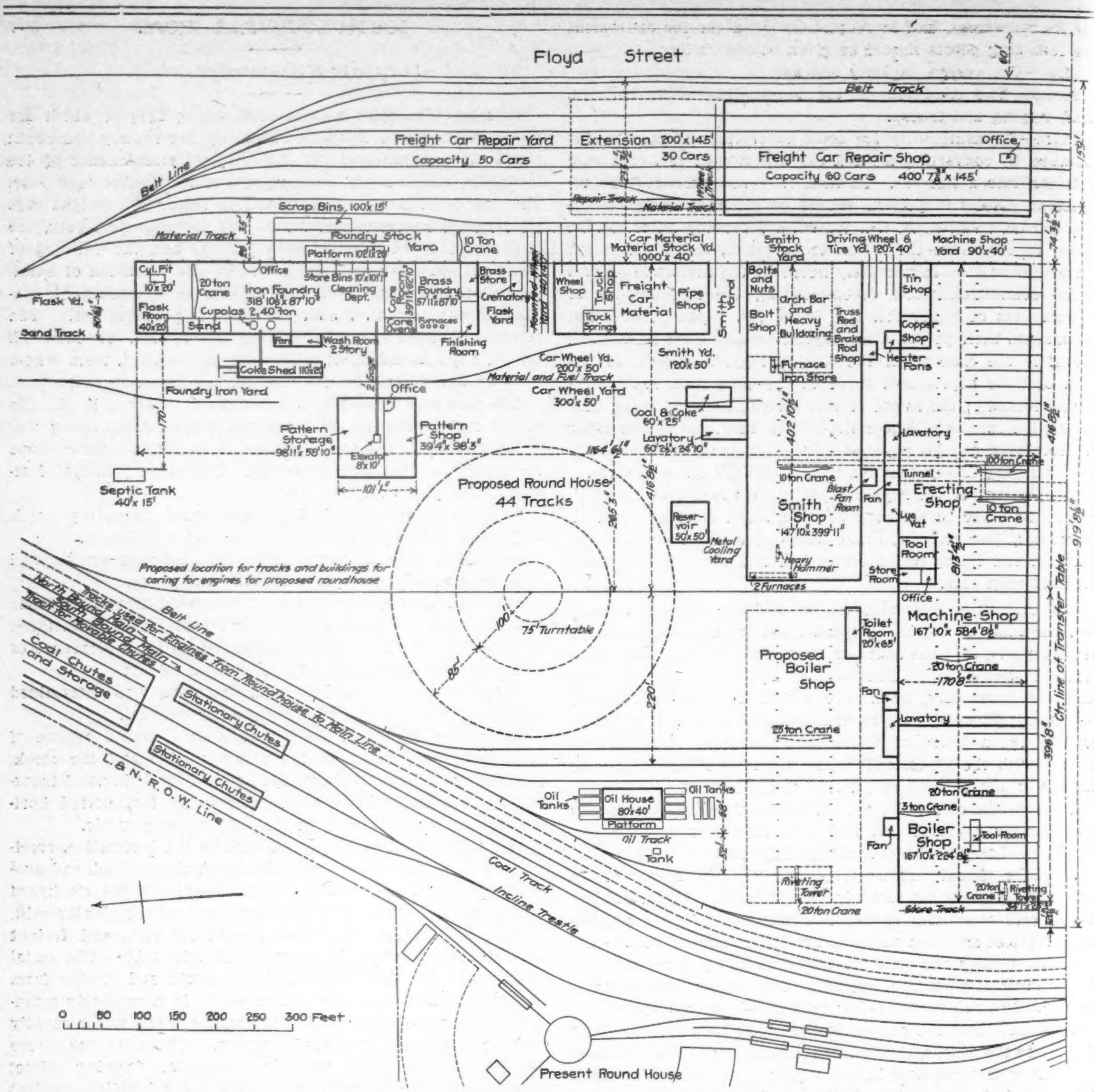
The grouping of the buildings, therefore, was determined largely by the problem of transporting material.

The central figure of the layout is an L-shaped avenue of transportation, formed by the transfer table and the stockyard crane. The metal parts are handled by lifting and transporting overhead, the wooden parts being transported horizontally on low cars with as little lifting as possible.

The metal working buildings, such as the locomotive, erecting, machine and boiler shops, the smith shop, wheel, and axle shop and the foundry, all connect directly to the stockyard crane, while the wood-working shops, such as the planing mill, cabinet shop, coach shop, new freight car shop and freight car repair shop, all border upon the transfer table. The metal parts enter the shop yards from the north and lumber from the south. Each operation on metals is in a southerly movement, passing into the metal working shops and under rapidly moving travelling overhead cranes. These cranes move in an easterly and westerly direction, forming direct connection with the stockyard crane. Each building receives its material from and delivers its product to the stockyard crane, and metal purchased in large quantities is delivered to this crane at its north end, this crane being available because of the grouping of the buildings for handling all material, whether manufactured at the shops or purchased outside, this being the receiving and distributing medium.

The wood in process of manufacture moves northward through the dry kilns or planing mill, and is delivered to the transfer table for distribution. The table also connects with the stockyard crane, and therefore becomes a part of the general receiving and distributing agent for all materials. By this arrangement metal parts move south and wood north, both using the L-shape avenue of transportation to distribute quickly and by mechanical means all the materials used at the plant. Hand labor is avoided by the mechanical equipment. While the transfer table is used generally for the product from the planing mill, it also may aid in an important way in getting material to the locomotive shops. This transfer table has a speed of 1,000 ft. per minute.

The track arrangement is such that switching may be done upon either side of the plant, and by use of the transfer table narrow-gauge yard tracks with turn-tables are avoided. Back of the planing mill is a sill yard, convenient to the dry kiln and south of the car shop buildings is a large yard with tracks at 60 ft. centers with a capacity of ten million ft. of lumber.



NEW LOCOMOTIVE AND CAR SHOPS, SOUTH LOUISVILLE, KY.—LOUISVILLE & NASHVILLE RAILROAD.

This lumber is handled on cars which are 2 ft. high, this height being adopted for all platforms in the lumber department, to avoid lifting and dropping heavy material. Lumber is loaded on kiln cars and kiln cars and lumber are transported on yard cars to the dry kiln, the kiln car passing through the dry kiln and again on to the yard car, and transported into the lumber shed or to the planing mill machines with only one handling of the lumber.

In the plan the crane service in the locomotive shop buildings is indicated. The plant has ten high-speed power cranes for rapid handling of material. The locomotive shop has transverse tracks served by the transfer table outside and by a 100-ton and a 10-ton electric overhead travelling crane inside. A careful study of the track arrangement will show that it would be impossible to tie up this plant by the failure of the cranes or transfer table.

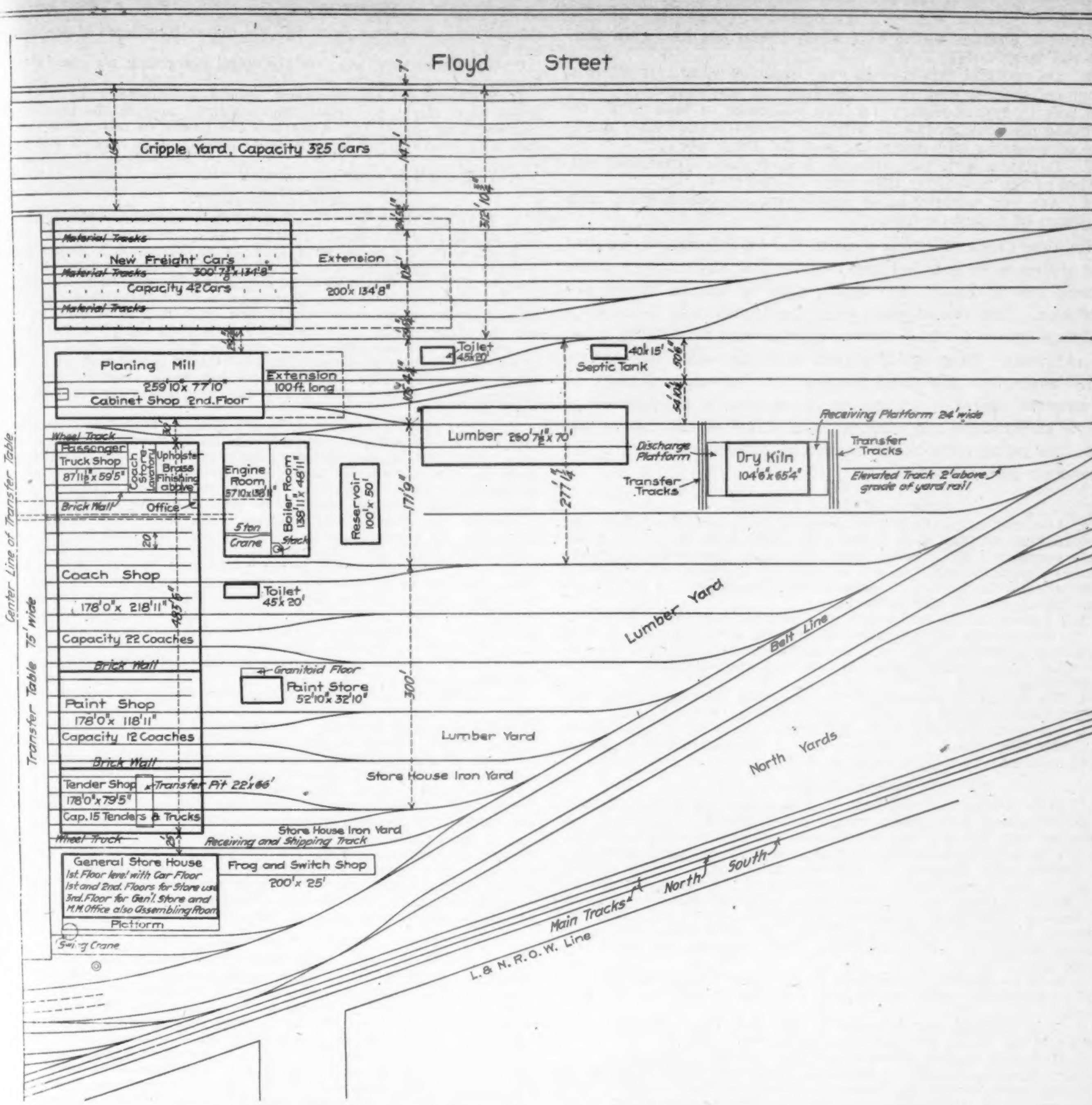
The power house was located near the planing mill in order to utilize the shavings from that department. As a part of the plan a 44-stall roundhouse is provided for, as indicated on the plan.

Climatic conditions were carefully considered in order to secure north light and avoid sunlight in the buildings, this being exceedingly important in the latitude of Kentucky. This arrangement takes advantage of the Southern breezes, which constitute an important factor in the hot season at Louisville.

A description of the departments in detail must be reserved until later. This plant was laid out by Mr. Theodore H. Curtis personally. The shop buildings were erected under the direction of the engineering department of the road, under the approval of Mr. Curtis. A thorough description of this plant will be presented when its organization and operation are complete.

A MATTER OF EDUCATION.

Progress in any other department of engineering during the past ten years has never been as great as that connected with the American locomotive. Locomotives have not only increased in size and power, but the methods of operation have changed radically in that time. In the extraordinary stress of business, requiring every available locomotive, practically all the time, pooling has become general, and the men operating locomotives have lost individual responsibility for and interest in the machines they run. Individual coal records were formerly important factors. Now they are not, and the



NEW LOCOMOTIVE AND CAR SHOPS, SOUTH LOUISVILLE, KY.—LOUISVILLE & NASHVILLE RAILROAD.

present tendency is toward complete abandonment of records which formerly tended to cause emulation among engineers for fuel saving. In fact, the prevailing types of coal chutes do not provide for either weighing or measuring the coal. When locomotives were small, the fuel question was important, from the standpoint of operating economy. With the present large engines economy is not less but more important, because the quantities are larger. But now we face another question. Compounding was introduced for reasons of economy. It was continued for reasons of capacity. American railroads adopt superheating and four-cylinder balanced compounding—not for reasons of economy, but for increased capacity.

CAPACITY is the goal locomotive people are striving for, and they have made much progress, but they have forgotten the factor which lies nearest at hand. They have forgotten the human element in control of the locomotive, which presents more possibilities than any other. The difference between the work of the best and the average man on a locomotive represents more to the road than the economies to be obtained from the best fuel-saving appliance or invention ever brought out. When it is appreciated that fuel saved because it is not burned affects the capacity of the locomotive, and increases the efficiency of heating surface, as does compounding and superheating, we shall pay more attention to the men who run the engines. It will not be disputed that, as a rule, the firemen who throw 3,000 lbs. of coal per hour receive less careful training and less preparation for their work than those who were required to throw but 1,000 lbs., in the past years. If American firemen and engineers were as efficient and as interested, personally and financially, in saving coal as are those of England and France, our locomotives would not need to be quite as big as they must be under our conditions to-day. We cannot take a backward step in size and power, but we must take a forward step in locomotive operation and pause a little in the march toward greater power.

An emergency may justify putting a man on a freight engine as fireman after only three days' instruction, but nothing can justify an average of only a week of training for a number of new firemen on a certain road last winter.

In order to ascertain whether the situation and possibilities are understood, a number of the highest railway officials in the country were asked by the editor the following questions:

"The president of one of our largest railroads has stated that he cannot secure as good men as engineers and firemen

of 100-ton engines as he had when 50-ton engines were considered large ones.

1. Do you find this true in your experience, and, if so, does it apply to other men on the road and in the shops?

2. Is it not necessary for the railroads to look after recruiting methods more carefully and to undertake better methods of selecting and preparing men for their work?

3. Is it advisable for railroads to undertake systematic education of the men after they enter the service?

4. Are you worried as to where you can secure good men in times of heavy business?"

Because these questions concern the labor question, most of the replies were guarded by a request that the author's name should not be given. For this reason all of the names are withheld. The letters come from the highest and best-known railroad officers in this country, representing over 80,000 miles of railroads. They indicate that some do and some do not fully appreciate the importance of the personal element in locomotive operation. That its importance is appreciated at all is encouraging. Abstracts from a few of the letters follow, the paragraphs being numbered to correspond with the questions stated above.

FROM A GENERAL MANAGER.

1. As a rule railroads are not securing as capable firemen at the present time as they were a few years ago when fifty-ton engines were considered large ones. For this same reason the engineers who are promoted from firemen are not as capable as the engineers who entered the service of roads several years ago. I do not believe this applies to men in the shops.

2. I believe we all realize the necessity of giving more attention to the employment of new men entering the service, especially firemen and brakemen, and, as a matter of fact, many roads are instituting a more rigid system of selecting and promoting men for their work.

3. We believe it is advisable for railroads to undertake a systematic education of men after they enter the service.

4. Owing to the very heavy and sudden increase of business on railroads throughout the country, it is a difficult matter to secure good men, and, to a certain extent, it is a source of great worry.

FROM A PRESIDENT.

1. It is within the recollection of men now in railway service (myself among the number) when firing light locomotives was a vocation that did not require men of extraordinary strength—in fact, I have known men of sedentary occupations to enter upon that of firemen with the view of regaining their health. With the advent of the large engine the duties of the fireman became so physically arduous that it is not now a question of brain, but one of brawn. We have, therefore, developed a set of men who are stronger physically, regardless of their mental aptness, and, as a whole, the men of to-day are not as good as the men of twenty-five years ago.

2. It is necessary for railroads to look after recruiting methods and to undertake better methods of selecting proper men for their work.

3. It is advisable for railroads to undertake the systematic education of the men after they enter the service.

4. Railroads which traverse thickly settled portions of the country have no trouble in procuring men, but roads which have outlying branches or run through sparsely settled country must have trouble in that direction. Taking into consideration, however, the fact that there are a million or more men employed on railroads in the United States (more or less of them floating about), for obvious reasons, it is quite possible to obtain skilled men to bridge over any ordinary or temporary increase in business.

FROM A SUPERINTENDENT OF MOTIVE POWER.

1. Either the requirements of the service have grown so rapidly that the average man is not keeping pace with them, or else we are not getting as good men. As a rule, our service is not as good, and the men do not seem to take the same interest in their work as they did when lighter equipment was used. I attribute this condition largely to the fact that each year brings out a better educated lot of young men. The work of firing a locomotive is hard and unpleasant, and young men will seek other positions and oftentimes take a lower rate of wages in order to avoid the hard and unpleasant work.

2. Railroads will have to look after their recruiting methods more carefully and make their positions more attractive in order to maintain the high standard of service which more modern conditions require.

3. I believe that railroads must undertake a systematic education of the men and make wages and conditions sufficiently attractive to draw a better class of men into the service.

4. In our experience, when business is heavy we are forced to accept the services of men that we would not have with us under any circumstances were it possible to get along without them.

These views may seem a little radical, but any railroad man who is in close touch with practical operation, if honest, will endorse them.

FROM A PRESIDENT.

1. The number of engines required to handle the increased business has increased in a greater ratio than it has been possible to drill and train enginemen, and, in consequence, a larger proportion of younger and less experienced men are forced into this service. Another reason, probably, why this condition exists is, as you know, on account of railroading being more exacting than it has been in past years, and, for this reason, men who might be considered first-class some years ago are not so considered at the present day.

2. Unquestionably, yes; we are doing everything we can in this direction.

3. Indirectly. This, however, should be carefully handled to avoid what might be termed "pauperizing" men in the matter of training and education. They are too prone to rely upon statements of instructors and fall back upon them in case of bad service.

4. Yes. This is a serious question with us.

FROM A PRESIDENT.

1. I do not think our experience has been exactly the same as that of the president of the railroad you quote as saying that it is impossible to secure as good men as engineers and firemen for 100-ton engines as for the 50-ton engines formerly used in our freight service. When we first began the introduction of heavier engines, something like five years ago, we did experience considerable difficulty through our enginemen, who had been used to the old and larger power with which we were then equipped, not doing as well with the new and heavier engines, and it took some time for our men to become accustomed to the heavier power, and we had to carry on a campaign of education for some time in order to thoroughly fit our men to handle the new power to the best advantage.

2. It is undoubtedly very necessary that the railroads hiring new men for service on their engines should be more careful in the selection of bright, intelligent young men, who, after their experience as firemen, will be better able to assume the duties of engineers than under conditions that existed fifteen or twenty years ago. I think, further more, it is very desirable for railroads to undertake to systematically educate the men who enter their service in the lower ranks so that they may be fitted for the more responsible duties that they will be called upon to perform in the event they are promoted to better positions. We are not particularly worried as to where we can secure good men in times of heavy business. It is a fact, however, that such men are not so readily available for employment when business increases steadily and sharply as formerly. I think the difficulty some of the railroads are having in securing men to handle their heavy power satisfactorily is due to a combination of conditions something like the following:

A considerable percentage of the older and more experienced engineers are dropping out of the railway service each year, either through death or disability on account of their age and the hard, trying service they have been subjected to as engineers. The services of a larger percentage of the balance of the old, experienced engineers are required to handle the increased number of passenger and preferred freight runs, leaving the handling of the heavy freight and switching power to the new men and those of the least experience, and these engines are more difficult and complicated to handle than the smaller and lighter power formerly used in freight service and to some extent still in passenger service. It seems to me some such reasons as these, instead of those suggested in your letter to me, are the ones which seem to indicate that the railroads are not able now to get the same service as formerly out of the enginemen on their new heavy power.

FROM A VICE-PRESIDENT.

1. The 100-ton and larger locomotives require more intelligent handling by the engineer, more vigorous firing by the fireman, and more accurate fitting by mechanics in the shops—therefore, it is necessary to have a higher standard of employes. The work of the engineer and the mechanic in the shop is increased very little, if any, due to the engineer to-day being called upon to do practically no work about his locomotive, and the man in the shop having the modern facilities for doing his work. The fireman is called upon to handle a greater tonnage of fuel, but his work is confined merely to the time on the road, whereas in the past it was customary to call upon him to do a great deal of cleaning on the locomotive, which is now materially reduced. The work throughout, however, calls for more care and intelligence than in the past.

2. It would be to the advantage of all railroads to do as many are now doing, viz., use the greatest care in selecting and employing new men, and, in all cases, ascertain if they are physically all right, also if they have the ability of developing and assuming increased responsibilities.

3. I think it is money well spent for railroads to have a systematic education of the men, after they have entered the service, and insist upon their men availing themselves of such opportunities as are given, promoting the men by the progress they make in this particular, rather than by seniority.

4. Precautions have been made in the past to have a surplus of competent men available for a heavy run of business, when this takes place. This is very important.

FROM A SECOND VICE-PRESIDENT AND GENERAL MANAGER.

1. We do not have any more difficulty in securing as good engineers and firemen for the larger engines than we had in getting good men for the smaller power, but, on account of the changed conditions incident to the larger power and general prosperity of the country, we have had more difficulty in retaining them, and changes are, therefore, more frequent. As to the men in the shops, we have more difficulty in securing good men than we formerly had, not, however, due to the large power, but to the increased prosperity of the country.

2. Our recruiting and selecting methods have not been changed, but the educational and physical requirements are more rigidly enforced than formerly, and more care is exercised in preparing men for this work.

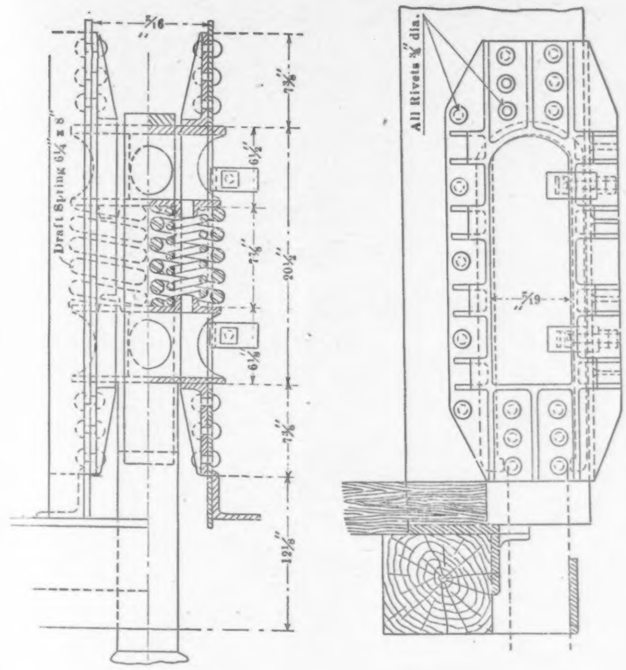
3. We find it necessary to undertake the systematic education and examination of enginemen after they enter the service, on the air brake and other appliances on locomotives.

4. We have had difficulty in getting men in times of heavy business, especially during the past two years, the greatest difficulty being in procuring a sufficient number of experienced engineers.

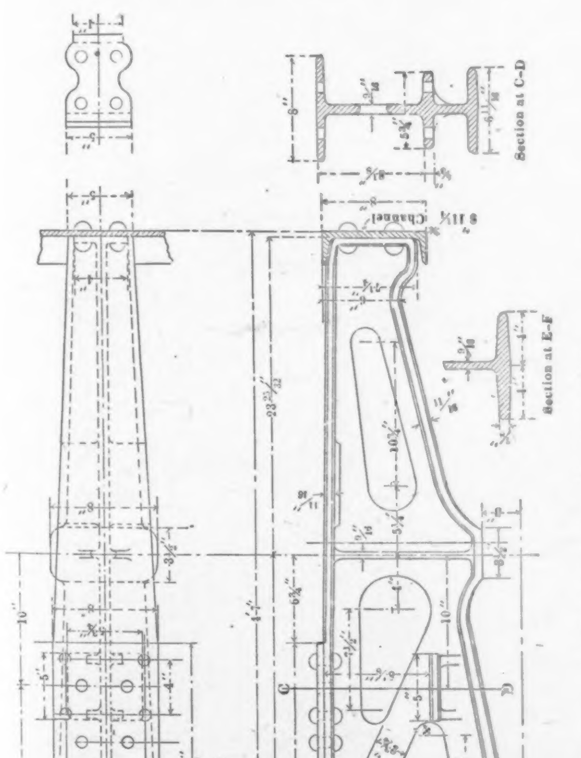
40-TON COMPOSITE HOPPER CARS.

SEABOARD AIR LINE RAILWAY.

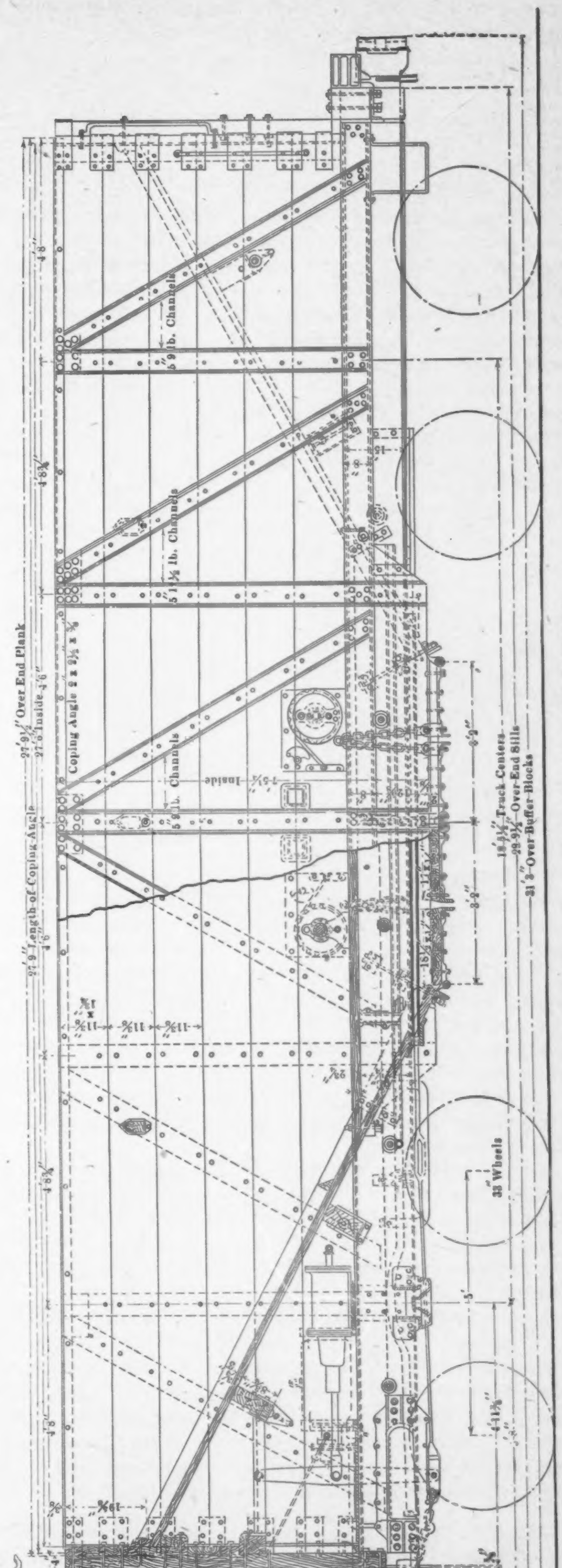
For coal traffic on the Seaboard Air Line a number of 40-ton composite cars have been constructed, using side frames to carry the load, the cars having been patterned after those of the same capacity which have been so successful on the Norfolk & Western Railway, and which are known as the design of Mr. C. A. Seley, formerly mechanical engineer of the Norfolk & Western. Mr. Seley's design is shown in this



DRAFT GEAR.



BODY BOLSTER CONSTRUCTION.



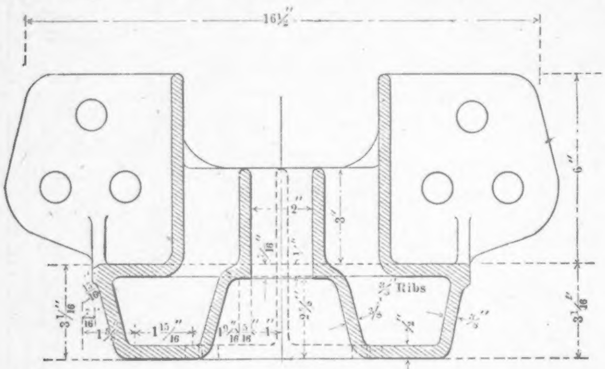
40-TON COMPOSITE HOPPER COAL CAR.—SEABOARD AIR LINE RAILWAY.

journal, in June, 1902, page 181. The general dimensions of the Seaboard Air Line cars are as follows:

Length over buffers	31 ft. 3 ins.
Length over end sills	27 ft. 9½ ins.
Length over body	27 ft. 9 ins.
Length inside	27 ft. 6 ins.
Width over sides	9 ft. 2 ins.
Width inside	8 ft. 9½ ins.
Height over hopper	7 ft. 5 ins.
Capacity	40 tons
Light weight	32,000 lbs.
Capacity, West Virginia coal	85,000 lbs.

The new features of this car are confined to the bolsters, draft gear and center plate construction. The bolsters are of steel castings, made in two parts with a coverplate connecting them over the center sills, the construction being such as to minimize the amount of fitting. The pressure at the bottom of these castings against the center sills is reduced by the large malleable iron center plate, which is of such a form as to take the load from the channels directly to the wearing surface of the plate.

The draft gear is of the twin spring type, the webs of the sills themselves being cut out to accommodate the gear. These holes are punched out in one operation. The cheek plates, which are of cast steel, are riveted to the sills, and the



CENTER PLATE.

metal added in this manner more than compensates for the amount removed by the punching. The draft of the twin springs is brought to the vertical webs of the steel channels, so that the stresses of buffing and pulling are transmitted into the central web of the backbone of the car. These springs are easily inspected from the outside, and by removing the two clips on one side the draft rigging is easily drawn out of the coupler yoke for repairs. Mr. R. P. C. Sanderson, superintendent of motive power of the road, states that this gear has been in use on a number of cars, and has been entirely successful.

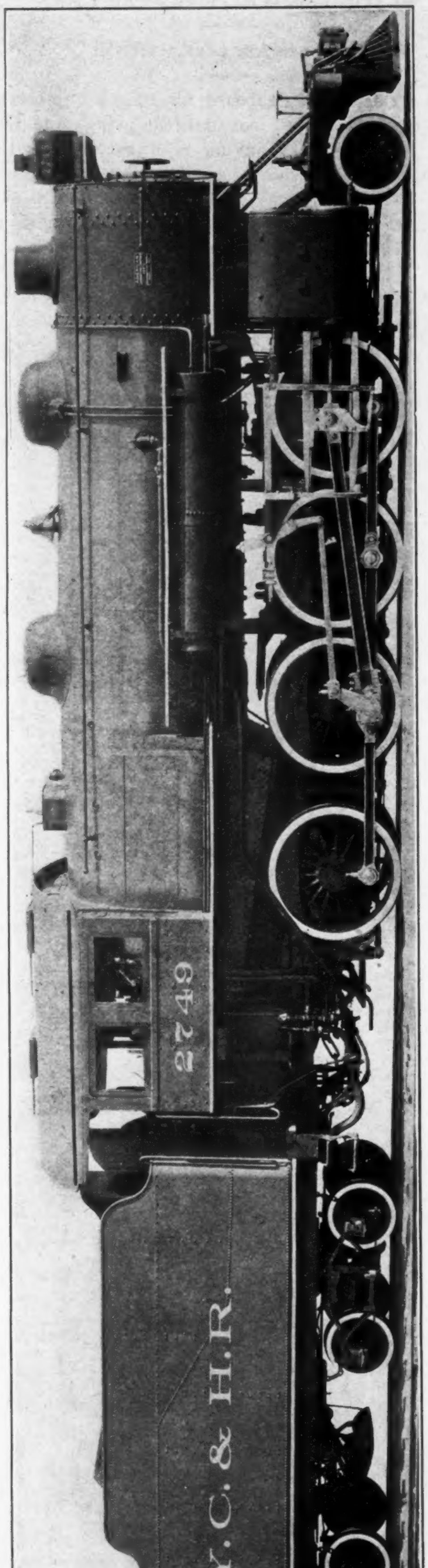
The adoption by the Norfolk & Western of this car construction is an additional mark of confidence in the design.

Descriptions of other cars of this kind may be found in this journal as follows: June, 1899, page 187; April, 1900, page 100; February, 1901, page 42; May, 1902, page 140; June, 1902, page 181; June, 1903, page 209; July, 1903, page 257.

We are indebted to Mr. Sanderson for these drawings.

Street Railways.—The mileage of the electric lines increased between 1890 and 1902 from 1,262 to 21,907, while there was a decrease for the lines operated by other motive power, the decrease being from 488 to 241 miles for cable lines, from 711 to 170 miles for steam lines, and from 5,662 to 259 miles for lines using animals for their motive power.

Efficiency of Motor Car Gearing.—French experiments on the efficiencies of gears fitted for motor car service give the following results in percentages for new and worn gears, respectively: Spur gearing, steel on steel, greased, exposed to street dust, 90 and 80; spur gearing, steel pinion and fibre gear wheel, 88 and 80; spur gearing, leather pinion and cast iron gear wheel, 88 and 80; spur gearing, steel on steel, running in an oil bath, 92 and 90; bevel gearing, steel and steel, in an oil bath, 88 and 82; universal joint, 95; roller chain, lubricated and exposed to the air, 94 and 92.—*Iron Age.*



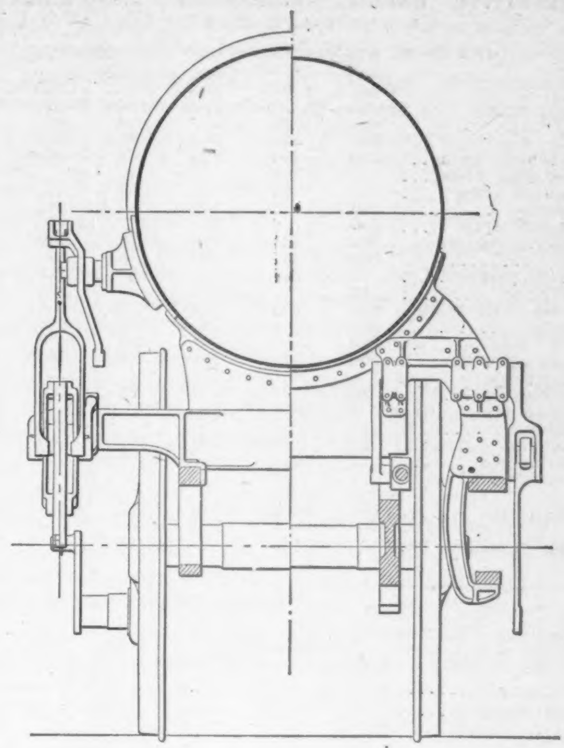
NEW YORK CENTRAL FREIGHT LOCOMOTIVE FITTED WITH WALSCHAERT VALVE GEAR.

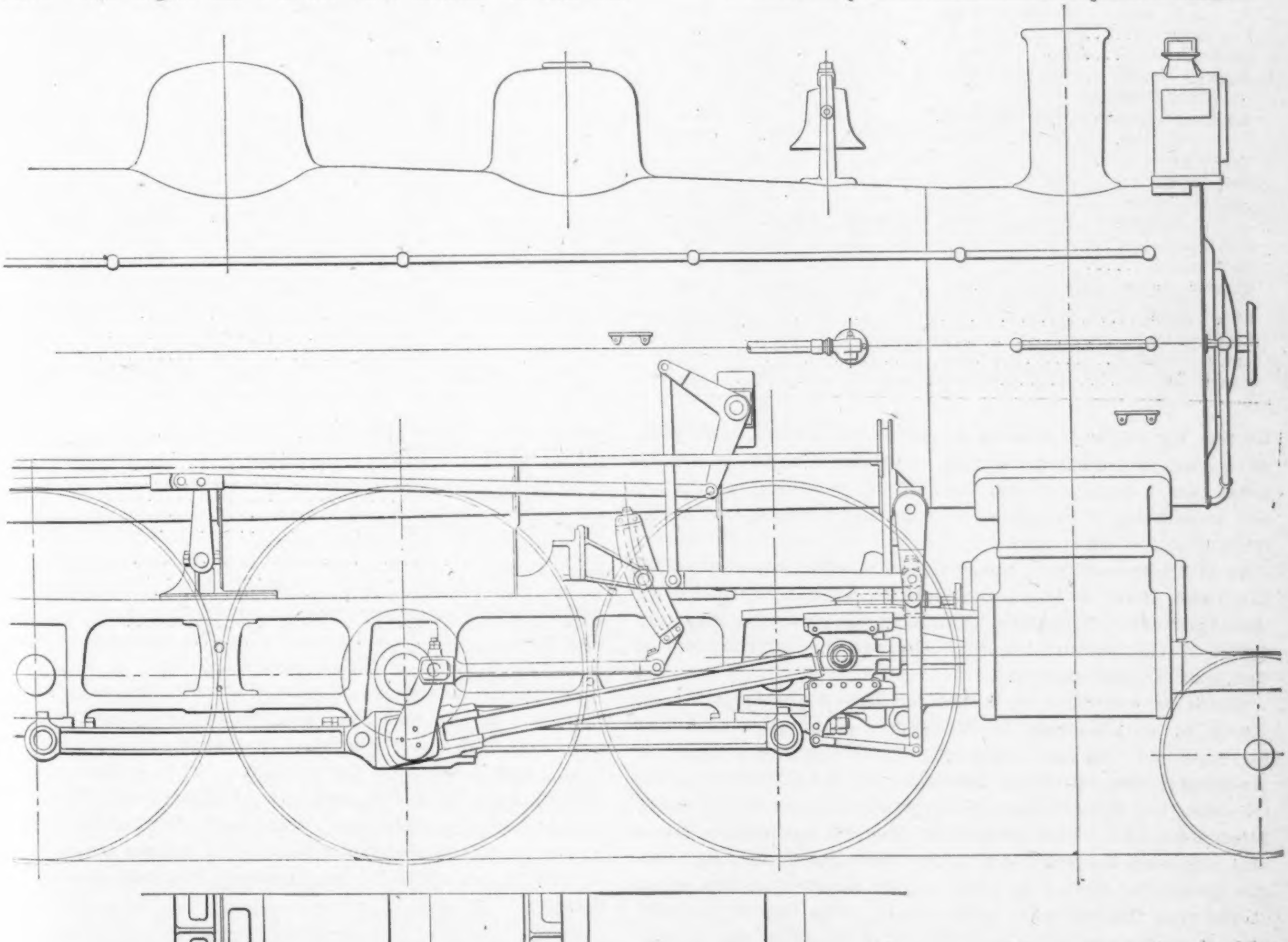
WALSCHAERT vs. STEPHENSON VALVE GEAR.

Walschaert valve gear is being seriously considered for use on Lake Shore locomotives. It has already been applied to a 2—8—0 locomotive (See AMERICAN ENGINEER, February, 1905, page 46), and service reports continue to be so favorable as to lead to the conclusion that it would be advantageous on passenger locomotives. This journal illustrated the Class J passenger locomotive in March, 1901, page 69, and the heavier Class K in November, 1904, page 413, and December, 1904, page 479. In the accompanying table the actual weights of the Stephenson gear are given for these three classes, the actual weights of the Walschaert for the 2—8—0 class, and estimated weights of the Walschaert gear for the two passenger classes. For Class K the saving in weight by using the latter gear is 1,745 lbs.

Since the application of the Walschaert gear to the Lake Shore locomotive, already referred to, it has been applied to a new consolidation locomotive, No. 2749, of the New York Central & Hudson River Railroad, a photograph of which is reproduced. This application is similar to that of the Lake Shore design.

In the line engraving the adaptation of the Class J, 2—6—2 passenger locomotive is illustrated. This locomotive was described in this journal in March, 1901, page 69, and the gear is to be applied in connection with an inside admission piston valve. This engine has a direct valve motion. In this con-





WALSCHAERT VALVE GEAR APPLIED TO PRAIRIE TYPE PASSENGER LOCOMOTIVE (CLASS J.)—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

COMPARATIVE WEIGHTS, STEPHENSON AND WALSCHAERT VALVE GEAR.

LAKE SHORE & MICHIGAN SOUTHERN LOCOMOTIVES.

	Class and Type					
	Class D, 2-8-0.		Class J, 2-6-2.		Class K, 2-6-2.	
	Stephenson. lbs.	Walschaert. lbs.	Stephenson. lbs.	Walschaert. lbs.	Stephenson. lbs.	Walschaert. lbs.
Crank pins, main	520	490	390	365	440	415
Crank pins, arms	..	100	..	80	..	90
Crosshead arms	..	60	..	50	..	50
Eccentric	600	..	740	..	740	..
Eccentric strap	800	..	880	..	1,120	..
Eccentric rods	200	220	200	175	280	200
Link	280	260	260	240	300	275
Link support	..	280	..	250	..	260
Link lifter	45	..	120	..	120	..
Reverse shaft & arms	260	400	350	375	385	390
Rockers	260	..	280	325	280	350
Rocker boxes	240	..	300	300	300	325
Transmission bar	300	140	270	160	300	170
Transmission bar hanger	80	72	120	65	120	75
Transmission bar bracket	..	..	..	..	200	..
Valve rod	80	70	130	100	100	100
Vibrating rod	..	220	..	180	..	180
Vibrating link	..	70	..	60	..	60
Total, lbs.	3,665	2,382	3,940	2,725	4,685	2,940
Saving in weight, lbs.		1,283		1,215		1,745

VALVE SETTING OF ENGINE 2749, WITH WALSCHAERT VALVE MOTION.

CUT-OFF POSITION. Forward Motion—	Pre-Admission.		Lead.		Port Opening.		Cut Off.		Release.		Closure.	
R. H. Side.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.
Full gear	0	0	3/16	3/16	2	2	27 13/16	26¾	30 1/16	30 1/16	1 15/16	1 15/16
Half stroke	7/16 S	7/16 S	3/16	3/16	9/16	9/16	16 5/16	16 1/16	25⅞	25⅞	6⅛	6⅛
Quarter stroke	11/16	11/16	3/16	3/16	¼	¼	8⅛	7 9/16	22	22	10	10
L. H. Side.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.
Full gear	0	0	3/16	3/16	2	2	27⅝	26 9/16	30 1/16	30 1/16	1 15/16	1 15/16
Half stroke	7/16	7/16	3/16	3/16	9/16	9/16	16	15 9/16	25⅞	25⅞	6⅛	6⅛
Quarter stroke	11/16	11/16	3/16	3/16	¼	¼	8	7 11/16	22	22	10	10
CUT-OFF POSITION. Backward Motion—	Pre-Admission.		Lead.		Port Opening.		Cut Off.		Release.		Closure.	
R. H. Side.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.
Full gear	0	0	3/16	3/16	2	2	27⅝	27¾	30	30	2	2
Half stroke	7/16	7/16	3/16	3/16	9/16	9/16	15¾	16⅞	25⅞	25⅞	6⅛	6⅛
Quarter stroke	11/16	11/16	3/16	3/16	¼	¼	6 13/16	8 1/16	22	22	10	10
L. H. Side.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back.
Full gear	0	0	3/16	3/16	2	2	27⅝	27⅜	30	30	2	2
Half stroke	7/16	7/16	3/16	3/16	9/16	9/16	16⅛	17⅞	25 13/16	25 13/16	6 3/16	6 3/16
Quarter stroke	11/16	11/16	3/16	3/16	¼	¼	6 3/16	7⅝	21 15/16	21 15/16	10 1/16	10 1/16

Link radius	65 ins.
Link centre	50 ins.
Valve travel	6 ins.
Steam lap	1 in.
Steam lead forward	3-16 in.
Steam lead back	3-16 in.
Clearance	0 in.

nection the table of weights of parts of the Walschaert gear, as applied to the Class J engine, are interesting, as it will be noted that a saving of over one-half ton in weight is effected, and in addition to this there is a marked advantage in accessibility of the valve gear.

It is understood that the Walschaert gear was applied on the Lake Shore & Michigan Southern at the suggestion of the American Locomotive Company, to whom belongs the credit of the present tendency towards the introduction of this gear in this country.

Attention was directed in the correspondence columns last month to an advantage in Walschaert gear which has thus far apparently escaped attention. It is this fact: That the Walschaert link not being influenced by a backing up eccentric, does not rock through as large an angle as the ordinary Stephenson link. This means that the link has a more favorable action on the link block in the Walschaert gear, and does not spring the motion as much as the Stephenson link when at and near the extremity of its stroke. The idea of the Walschaert gear seems to be very favorably received, and a number of other roads are considering its adoption. The following table gives the dimensions of the New York Central locomotive:

CONSOLIDATION LOCOMOTIVE—WALSCHAERT VALVE MOTION.

NEW YORK CENTRAL & HUDSON RIVER R. R.

GENERAL DATA.	
Gauge	4 ft. 8½ ins.
Service	Freight
Fuel	Bituminous coal
Tractive power	45,700 lbs.
Weight in working order	226,000 lbs.
Weight on drivers	201,000 lbs.
Weight of engine and tender in working order	369,200 lbs.
Wheel base, driving	17 ft. 6 ins.
Wheel base, total	26 ft. 5 ins.
Wheel base, engine and tender	60 ft. 6½ ins.
RATIOS.	
Tractive weight ÷ tractive effort	4.
Tractive effort x diam. drivers ÷ heating surface	77
Heating surface ÷ grate area	65.
Total weight ÷ tractive effort	4.
CYLINDERS.	
Kind	Simple
Diameter and stroke	23 by 32 ins.
Piston rod, diameter	4 ins.
VALVES.	
Kind	14-in. Piston
Greatest travel	6 ins.
Steam lap	⅞ ins.
Exhaust lap	Line and line
Lead in full gear	Line and line
WHEELS.	
Driving, diameter over tires	63 ins.
Driving, thickness of tires	3½ ins.
Driving journals, main, diameter and length	10 by 12 ins.
Engine truck wheels, diameter	33 ins.
BOILER.	
Style	Straight top
Working pressure	200 lbs.
Outside diameter of first ring	81⅝ ins.
Firebox, length and width	108 1-16 by 75¼ ins.
Firebox, plates, thickness	⅜ and 9-16 in.
Firebox, water space	4½ ins.
Tubes, number and outside diameter	446 2-in.
Tubes, gauge and length	11, 15 ft. 0½ ins. long.
Heating surface, tubes	3,489.47 sq. ft.
Heating surface, arch tubes	27.41 sq. ft.
Heating surface, firebox	185.64 sq. ft.
Heating surface, total	3,702.52 sq. ft.
Grate area	56.25 sq. ft.
Exhaust pipe	Single.
Smokestack, diameter	20 ins.
Smokestack, height above rail	14 ft. 9¾ ins.
TENDER.	
Tank	Water bottom.
Frame	10-in. channels.
Weight, loaded	143,200 lbs.
Wheels, diameter	33 ins.
Water capacity	7,500 gals.
Coal capacity	12 tons.

ENORMOUS HEADS FOR WATER WHEELS.—The Abner Doble Company, of San Francisco, has recently installed three 7,500-h.p. tangential water wheels at the electric plant of the California Gas & Electric Corporation. They operate under a 1,250-ft. head of water, and run at 400 r.p.m. Two 75-h.p. Doble exciter wheels have been built for the Pike's Peak Hydro-Electric Railway of Colorado, to operate under a head of 2,100 ft., which is the greatest head of water in the United States.

TIRE STEEL.—The proper chemical composition of tire steel is an open question. Some roads specify 0.60 to 0.75 carbon and 0.20 to 0.30 silicon, and others specify lower contents of both of these. The Pennsylvania specification for passenger and freight is as follows:

Carbon	0.55 to 0.70
Silicon	0.10 to 0.20
Manganese	0.60 to 0.75
Sulphur, not to exceed	0.06
Phosphorous, not to exceed	0.05

—(*P. H. Dudley, before Int. Ry. Congress.*)

A LARGE SINGLE PHASE LOCOMOTIVE FOR HEAVY RAILROAD SERVICE.

Of the many interesting exhibits of railway appliances prepared for the inspection of the delegates to the International Railway Congress, probably the most novel, and certainly the most important in its bearing on the use of electricity as a motive power for heavy railroad service, was the Westinghouse-Baldwin single phase, alternating current locomotive, shown in operation May 16th on the Interworks Railway at East Pittsburgh. This locomotive was built by the Westinghouse Electric & Manufacturing Company in order to convince the railway managers of the possibilities and advantages of the use of single phase current for the heavy electric traction, and to demonstrate the ability of the company to supply the necessary apparatus. It was shown in operation first running light and then hauling a train of fifty new steel gondola cars, weighing, approximately, 1,200 tons.

This is the largest alternating current locomotive in the world, the largest to be operated by a single phase current, and it is equipped with six of the largest single phase motors ever built. It is the first alternating current locomotive for use in America, and is designed for the highest trolley voltage ever used in this country. This locomotive is also the largest ever operated by means of overhead trolleys, is the first on which forced ventilation is used on the motors, and is unique in other respects.

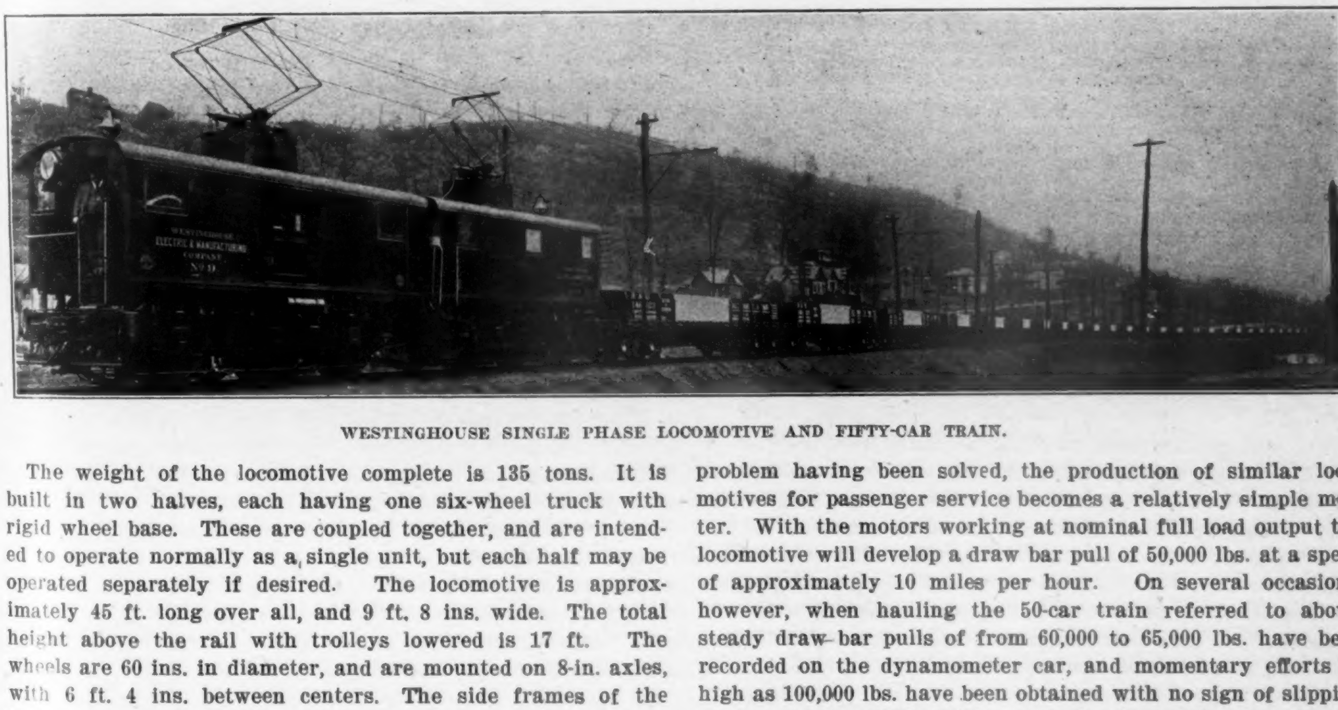
The weight of the locomotive complete is 135 tons. It is built in two halves, each having one six-wheel truck with rigid wheel base. These are coupled together, and are intended to operate normally as a single unit, but each half may be operated separately if desired. The locomotive is approximately 45 ft. long over all, and 9 ft. 8 ins. wide. The total height above the rail with trolleys lowered is 17 ft. The wheels are 60 ins. in diameter, and are mounted on 8-in. axles, with 6 ft. 4 ins. between centers. The side frames of the truck are of cast steel and are spring supported in the usual manner, the weight on the two inside axles of each truck being equalized. The cabs are built of sheet steel with angle iron supports, and the entire cab as a whole is removable from the truck. Each axle carries a 225 h.p. single phase series motor of the single reduction geared type, making a total of six motors for the locomotive. One side of each motor is supported directly on the axle and the other is suspended by spiral springs from the locomotive body. The motors are of the same general construction as the standard Westinghouse alternating current railway motors of smaller size which have been previously described in these columns. They are so arranged that forced ventilation may be used and increased output thus secured.

The locomotive is designed for a current of 25 cycles and a trolley voltage of 6,000, and one of the most striking points of the exhibition to those who have been accustomed to the enormous currents required in heavy direct traction work was the sight of so large a locomotive accelerating a 1,200-ton train over a third of a mile in length and receiving its entire power supply from a single No. 000 trolley wire. The 6,000-volt current is collected from the trolley wire by a pneumatically operated pantagraph trolley on each half of the locomotive, and is carried through a suitable oil switch and circuit breaker to an auto-transformer in each cab. These transformers reduce the voltage to 325 for use at the motors. The trolleys may be raised or lowered from the cab by a suitable air valve.

The three motors on each half of the locomotive are connected permanently in parallel and are controlled by means of an induction regulator, which, under the direction of the operator, varies the voltage at the motors from about 140 to 325. The induction regulators are driven by small series motors of the same general type as the main motors. Both regulators are controlled by the multiple unit system from a master switch at either end. They may be stopped at any desired point in their travel, and thus the locomotive may be run at any speed with the same facility and economy as a steam locomotive. Forced ventilation is used with the auto-transformers and induction regulators as well as with the motors, the necessary air being supplied by motor-driven blowers. Motor-driven air compressors are also used.

The locomotive is designed for slow speed freight service, this type having been chosen because the design of series alternating current motors for very slow speed service presents many more problems and is much more difficult than the design of equal capacities for the ordinary conditions. This problem having been solved, the production of similar locomotives for passenger service becomes a relatively simple matter. With the motors working at nominal full load output the locomotive will develop a draw bar pull of 50,000 lbs. at a speed of approximately 10 miles per hour. On several occasions, however, when hauling the 50-car train referred to above, steady draw-bar pulls of from 60,000 to 65,000 lbs. have been recorded on the dynamometer car, and momentary efforts as high as 100,000 lbs. have been obtained with no sign of slipping of the wheels. With lighter loads the locomotive may be run at higher speeds up to a maximum of about 30 miles per hour.

The successful completion of so large and powerful an alternating current locomotive without the usual series of developments through gradually increasing sizes, which is ordinarily required when so great a problem is undertaken, marks a distinct advance in the production of electrical apparatus for heavy traction work.



WESTINGHOUSE SINGLE PHASE LOCOMOTIVE AND FIFTY-CAR TRAIN.

INDEPENDENT MOTOR COACH.—The Glasgow & Southwestern Railway, of which Mr. James Manson is locomotive superintendent, has built an independent steam motor coach, with the locomotive and coach on a single frame, which is 60 ft. 8 ins. long over end sills. The car seat 50 passengers. The length of the body itself is 41 ft. The diameter of the wheels is 42 ins. The locomotive has 9 x 15-in. cylinders and a horizontal boiler, with 8 sq. ft. of grate surface and 440 sq. ft. of heating surface. The boiler has 138 1⅝-in. tubes. This unit is for use in local traffic.

(Established 1832).

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We cordially invite our many friends attending the conventions at Manhattan Beach in June to make use of our offices. Telegrams and mail addressed in our care will receive careful attention.

LOCOMOTIVE REPAIR ACCOUNTS.

The system of locomotive repair accounts introduced by Mr. H. H. Vaughan, superintendent of motive power of the Canadian Pacific, is described by him on another page of this issue. This article should be taken under serious consideration by every motive power and operating official because of the importance of motive power records in the operation of railroads. It is believed that no more important suggestion than this has ever been made with respect to the records of the cost of locomotive maintenance.

PERFORMANCE OF BALTIMORE & OHIO MALLET COMPOUND LOCOMOTIVE.

Those who have predicted all kinds of troubles and failures with the large Mallet articulated compound locomotive, built by the American Locomotive Company for the Baltimore & Ohio Railroad, and illustrated in this journal in June of last year, should carefully note the statements by Mr. J. E. Muhlfeld, superintendent of motive power of that road, which appear elsewhere in this issue. The locomotive has been entirely successful, and Mr. Muhlfeld presents interesting figures concerning 60-mile freight runs and 15-mile pusher runs. His statements are of great importance in view of the advantages offered by the Mallet type of construction for large locomotives. This locomotive seems to be just the thing for heavy mountain service, and strong arguments for using the same type of construction for heavy road locomotives may be based upon this experience. Especially noteworthy is the fact that the work described was performed with the service of but one fireman.

ELECTRICITY ON STEAM RAILROADS.

The paper on "Electricity on Steam Railroads," presented before the Western Railway Club by Mr. Clement F. Street is the most complete and valuable contribution on this subject which we have seen. The paper is such that it cannot properly be presented in abstract, and those interested should obtain complete copies of it. Mr. Street states that the indications are that within the next few years a large proportion of the heavy suburban service, the demands of which are even now beyond the capacity of steam locomotives, will be handled by electric equipment. The next service in which it will be introduced will be for pushers on heavy grades, and from this and suburban service extensions will be made to entire divisions and trunk lines, although the extensions to the trunk lines will not be made in the near future.

The benefits to be gained from the electrical operation of suburban service are as follows: Increase in gross receipts, better application of power to trains, increased capacity of terminals, reduction in operating expenses, reduction in terminal costs, reduction in cost of maintenance of equipment, increased reliability of service and reduction in coal consumption. Instances are cited where the gross receipts of suburban roads have increased from 46 to 68 per cent. after the introduction of electrical operation. A system of traction having power units attached to the trucks of the cars is desirable in suburban service for the following reasons: A high rate of acceleration can be obtained; a change in the weight of the train does not cause a corresponding change in the rate of acceleration; the rate of acceleration can be changed to suit different conditions; switch engines are not required, and the draw bar strains are distributed. The capacity of terminals is increased, since only one or two switching operations are required with electrically operated trains, while from 5 to 7 operations are required with steam locomotives, and considerable time is also saved due to the quicker acceleration of the electric trains.

With electric cars the terminal costs are reduced by about 60 per cent., and the investment in buildings and equipment by 80 to 90 per cent. Roundhouses, cinder pits, boiler washing, cleaning of flues and grates, packing of cellars, firing up of engines, turn-table expenses and coal trestles are eliminated. Assuming that six car trains can be operated with one locomotive or three motor cars, the terminal cost of the electric equipment per day is about 65 cents, as compared to $1.53 for the locomotive. Statistics which are presented indicate that the cost of maintenance of equipment is much less for electric than for steam roads.

Mr. Street considers at length the different systems of electric traction and the relative advantages of the third rail and the trolley. He advocates the use of the single-phase alternating current system and an overhead conductor.

INTERNATIONAL RAILWAY CONGRESS.

An idea of the scope of the recent meeting of the International Railway Congress in Washington is conveyed by the fact that forty-six different countries were represented by delegates, the number of railroads being 404, the total number of delegates 568, of which 286 were foreign and 282 American. The railways represented aggregated 310,940 miles. While the delegates met for the consideration of a large number of subjects concerning railway transportation, the convention itself was by no means the most important feature of this assemblage of those who are conducting the most important development of the time. Aside from the foreign delegates, never before has there been such a gathering of American railway officials, including owners, financiers, managing, engineering and motive power men. The Congress may be considered an epoch-making event, making for a better understanding not only among railway men of different countries, but among those of this country, and the lesson of the Congress is the importance of occasionally getting together

all the officials of all the departments for a study of their common problem.

The value of the official discussions would have been much greater if those other than delegates were permitted to know exactly what was said in the meetings. The reports of the discussions, after the censors had finished with them, were robbed of much of their value and it is to be hoped that at some future time the star chamber character of the discussions may give place to a more modern and enlightened plan, as there can be no satisfactory reason at this day and date for discussing technical railroad subjects behind closed doors.

As is usual on such occasions, intercourse during leisure moments on the excursions and at the banquets, was an exceedingly valuable feature of the gathering. No one could attend, in the proper spirit, without deriving hundreds of inspirations from the men he met who are earnestly devoting themselves to transportation.

Comments from various prominent officials were heard. A well known general manager stated that "This is the best convention of any kind I ever attended." Another said: "Great good will come from this assemblage of serious-minded, able men of the highest responsibilities, and noblest purposes."

Undoubtedly the strongest feature of the convention was the remarkable exhibit of the American Railway Appliance Exposition with over 300 members and exhibitors. These exhibits were representative of American railway appliances in an effort to show our practice to foreigners, and its scope was so great and the individual exhibits so good as to warrant the statement that American railway officials could derive more from it than could the foreigners. Among the mechanical appliances there were few that were new to those who are carefully watching progress. Throughout the exhibition, however, were many new applications which have not been seen at any previous exhibition. The value of this feature of the Congress centered in the fact that the owners, presidents, general managers and other high officials, mingled with their department subordinates in making a careful study of equipment and appliances.

At a casual gathering of nine or ten railroad presidents one evening the decision was reached that they should send for their mechanical and engineering officials. One road sent a delegation of 26 men; from other roads representatives visited the exhibits in groups of five or six and in many cases these men were required to render reports of what they saw. One of the exhibiting companies had a force of 40 men at the Congress. This company had appropriated $35,000 for its expenses, including the exhibit. Such men as Mr. Stuyvesant Fish expressed the opinion that the exhibition was the most important feature of the Congress. To one who carefully studied the exhibits and noted the care with which they were examined by the higher officials it must have been evident that this exhibition has performed a mission in raising the dignity of the motive power problem by showing the higher officials how great the problem is.

It would be useless to attempt a description in detail, but it is sufficient to say that a week was too short a time for a complete study of the exhibition. The attendance averaged over 2,000 per day. The value of the results cannot possibly be estimated. The exhibition was of the most definite character, classified along straight lines, leading in the direction of improvement in developing track, operation and shop practice, making for economy, celerity of work and service and certainty as well as safety of operation. If the railroads and their very high officials have learned the lessons of this Congress they have obtained a better insight into the problems of operation than was ever possible to obtain before.

For this remarkable exhibition great credit is due the American manufacturers of railway equipment and appliances. No previous exhibition has ever approached the importance of this one and another like it is not to be expected for some time to come.

Taken as a whole, the gathering at Washington was a complete and unqualified success from the American as well as the foreign standpoint.

NEGLECTED APPRENTICESHIP.

Proper provision for the men of the future in shops, on locomotives, on the road, at the telegraph key, and everywhere else on railroads, is being neglected to an extent which is absurd, ridiculous and positively unsafe. A day of reckoning is to come, and our brightest, ablest and strongest railroad officials are to be judged and found wanting, unless they awake to the situation and meet the need promptly, thoroughly and permanently.

There are tons of literature on the subject of apprenticeship, yet so little is actually done as to justify the statement that, while the principles are understood, apprenticeship is neglected by American railroads.

Many trades are represented in a modern railroad shop, often numbering twelve or more. It is the exception rather than the rule to find half of these trades provided with apprentices. As important a trade as boiler-making is usually entirely barren of apprentices.

In the editorial office of this journal damaging evidence may be shown to incriminate railroad officers in the use of apprenticeship on important machines to keep down the cost of locomotive repairs. Complaint is made that the labor unions restrict the number of apprentices. This is true—but the use made of the boys and the lack of training in the shops warrants the statement that those we have are abused. Notable exceptions only prove the rule.

These criticisms are not confined to apprentices. During the past year firemen have been put to work with woefully insufficient training. What can be expected of a man firing a heavy freight locomotive after only one week of instruction, and that confined to what is given him by the fireman he works under on the locomotive. Even the electric street railroads do better than this with their motormen.

These facts are known to the officials. What is the reason for the distressing neglect of recruiting methods and apprenticeship in general?

The reason is simple. It is no one's special business to look after the men of the future, and the higher officials are too busy with the present to think of the future. That is all, and when the facts which are now known become appreciated a wave of improvement will sweep the country from end to end. This wave cannot start too soon. It is already about twenty years behind its schedule.

Here are some pointed questions for presidents, general managers and superintendents of motive power:

What has become of the *esprit de corps* of railroad organizations of a generation ago?

What are the railroads doing to meet the new conditions of management of men arising because of the increase in size of railroads and their aggregation into systems?

What has become of the apprenticeship under which you grew up?

What policy are you pursuing in order to direct the natural leadership talent among your men into useful and helpful channels?

Why do you ever go outside of your own staff of subordinate officials and men to fill important positions?

From the standpoint of organization, what are you doing to render your successor's position easier than yours has been?

As to organization, what can railroads learn from a large army?

Why has special apprenticeship of college men proved a failure in the matter of providing subordinate and higher officials?

This may not be a popular subject, but it must not be laid aside for that reason. It is time that a warning should be sounded in this most important tendency toward trouble in the future. It is not sufficient to provide evening schools for one or two subjects. Evening schools may form the basis for building up for the future, but they cannot present a solution of the problem now facing the railroads. A new apprenticeship with a new educational system is needed.

WALSCHAERT VALVE GEAR.

American locomotive development during the past twenty-five years has not brought the improvements of valve gear mechanism up to correspond with other improvements of our powerful locomotives. American railroad officials and locomotive designers have continued to apply the old Stephenson link motion practically to the exclusion of all other valve motions. While this gear has proved successful on locomotives of moderate size and has given good satisfaction, it has been impossible, on account of the limitations of gauge of track and the enlargement of the other parts of the locomotive, to increase valve gear proportions in proper ratio. The size of eccentrics is not proportionately larger upon the largest engines now built than upon the small engines of a quarter of a century ago. Consequently the wear, breakage and renewals of these parts is greater than it should be. If, however, the size of eccentrics could be increased proportionately to the size of the locomotive, they would give trouble because of high surface velocity.

European locomotive builders during this period have been in advance of us and have for a number of years used the Walschaert valve gear. Probably 90 per cent. of the main line passenger and freight locomotives annually built upon the continent are equipped with it. English locomotive men have, like ourselves, been slow to change from the Stephenson link motion, but in this they are more excusable because the small size of their engines still permits of proper proportions for the work performed.

Realizing that the limitation of the Stephenson link motion has been reached, the American Locomotive Company last year adapted the Walschaert valve gear to the Mallet compound locomotive built for the Baltimore & Ohio Railroad and exhibited at the St. Louis Exposition. This engine, which has been illustrated in this journal in June, 1904, page 237, is a 4-cylinder articulated compound, the heaviest and most powerful ever constructed. While this type of valve gear has been previously used in this country upon small locomotives and small motor cars this was its first application to a heavy American road locomotive. As recorded in this journal it has since been applied to heavy consolidation locomotives for the Lake Shore & Michigan Southern and the New York Central & Hudson River railroads. The American Locomotive Company is recommending the adoption of Walschaert gear to all types of heavy locomotives, both for the highest speed passenger service and the heaviest and slowest freight service.

This gear is specially well adapted to modern high efficiency engines, and on account of the construction which places all the heavy wearing surfaces outside of the wheels, where they are readily accessible for inspection and lubrication, the gear has met with unexpected favor from all classes of railway officials as well as the men who run the engines.

OPERATION.—The Stephenson gear increases the lead as the cut-off is shortened. The Walschaert gives a constant lead at all cut-offs from full to mid-gear. The constant lead is an advantage, as in the case of the link motion it is a difficult matter to obtain sufficient lead with large cylinders in the longer cut-offs and at the same time keep down the lead and consequent pre-admission and excess of compression in the shorter cut-offs where most of the high speed work is performed. The advantages of constant lead on large cylinder engines is manifest because of the possibility of giving an amount of lead in long cut-offs to properly cushion the reciprocating parts and at the same time reduce the pre-admission and compression of short cut-offs, thus making a freer working and easier running engine, saving steam and reducing the pounding of bearings.

CONSTRUCTION.—The valve is operated by means of a slotted link of suitable radius, pivoted at its center and reciprocated by a connecting rod attached to its lower end, the connecting rod deriving its motion from a return or eccentric crank secured to the main crank pin. The valve stem is connected to the link by a pivoted transmission bar, which is raised and lowered in the link by means of the reverse lever, the varying positions of the block in the link controlling the cut-off from full gear ahead to mid-gear and thence to full gear in backward motion.

If the valve were actuated by this combination alone there would be no lap or lead, consequently it was necessary to supply a secondary motion to give the necessary lap and lead. This is done by means of a pendulum lever, the upper end of which is attached to the valve stem and the lower connected to the cross head by a suitable link. The transmission bar is pivoted to this lever at its upper end, the ratio between the pivot point being that of half the travel of the cross head to the lap of the valve plus the lead. A motion is thus obtained which causes the valve to perform its proper function in an arrangement which brings the connections into practically the same vertical plane, thus centralizing the strains in approximately straight lines. Where the distribution valves are located in the cylinder saddle they are operated by means of an ordinary rocker shaft. All connections have case-hardened pins and lubricated bushings, except that upon the return crank pin, which is fitted with an adjustable bronze bearing. It will readily be seen that this motion possesses superior advantages, which may be summed up as follows:

ADVANTAGES.—Reduced weight of moving parts of the valve gear, reduced first cost when compared with bronze eccentric straps, reduced cost of maintenance, accessibility of all parts for inspection, accessibility of all parts for lubrication, elimination of frequent renewals and repairs, a construction permitting better and stronger bracing of frames, construction permitting the use of longer driving box bearings, easier access to main driving box cellars. This motion does not "get out of square" like the Stephenson motion, but the valves retain their original setting.

The Walschaert gear is not new, but is introduced into American parctice to meet the conditions of heavy road service because of conditions which are new. Egide Walschaert was born near Brussels in 1820. While in the service of the Belgium State Railways he patented his valve gear in 1844. This valve gear eventually became the valve gear of Europe. He died in 1901 near Brussels at the age of 81 years. We may pay tribute to his genius in having developed over 60 years ago something which we find we greatly need to-day.

CAST IRON WHEELS IN PASSENGER AND FREIGHT SERVICE.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

The Chicago, Milwaukee & St. Paul Railway is a notable example of a road making general use of cast iron wheels in passenger as well as freight service. From the wheel records which have been carefully kept since 1885, interesting information is obtained. In this journal for June, 1889, page 191, the record up to that date was published. Mr. A. E. Manchester, superintendent of motive power, has kindly supplied the figures bringing the record down to date.

Attention should be directed to the fact that the average mileage is obtained by dividing the total car mileage during any year by the number of wheels taken out. If 10,000 wheels are in service and 1,000 are removed each year, the average length of service would be 10 years, and the average mileage would be 10 times the yearly mileage of the cars. This does not give accurate figures for any particular year, but it does give a correct method of comparison when a number of years are covered, and the statement shows the average mileage of all wheels taken out for all causes.

The shorter life of freight wheels shown for the years 1903 and 1904 is due to two causes. During the last five years this company has added to its equipment a number of 40 and 50-ton cars, which are special cars, used in ballast, ore and coal service. These cars make more mileage than other cars in general service, and the weight of the cars and their greater mileage account for the reduced mileage of the wheels. Furthermore, in all of the heavier equipment the inspection of

wheels is more rigid, and they are withdrawn when in better condition than was the practice with the older equipment. This record, therefore, shows the results of heavier cars, and is exceedingly important in the experience with cast iron wheels on this road. It is significant that the records for the last two years are below those of the previous 13 years.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY COMPANY, MOTIVE POWER DEPARTMENT.

COMPARATIVE STATEMENT, SERVICE OF FREIGHT CAR WHEELS, YEARS 1885–1904.

Year.	Number of freight wheels made or bought for repairs	Freight car mileage.	Number of freight cars.	Number of freight wheels in service.	Average mileage.	Average life of wheels. Days.	Months.	Years.
1885....	22,395	215,459,302	19,402	155,216	76,968	6	11	15
1886....	19,459	236,140,449	21,385	171,080	97,080	8	9	15
1887...	24,721	250,774,965	21,678	173,424	81,152	7	0	1
1888...	24,162	261,400,022	22,544	180,352	86,544	7	5	17
1889...	26,015	250,990,286	22,776	182,208	77,184	7	0	1
1890...	15,823	263,983,845	23,864	190,912	133,468	12	0	24
1891...	12,810	305,482,341	25,674	205,392	190,776	16	0	12
1892...	17,340	334,943,674	26,308	210,372	154,528	12	1	18
1893...	17,332	312,503,242	27,963	223,612	144,240	12	10	24
1894...	11,647	276,300,355	27,800	222,400	189,784	19	1	4
1895...	14,219	289,316,350	27,687	221,408	162,776	15	6	26
1896...	19,569	315,810,431	27,645	221,072	129,104	11	3	22
1897...	14,634	292,285,995	27,517	220,048	159,784	15	0	13
1898...	19,420	344,752,791	30,120	240,876	142,020	12	4	25
1899...	19,304	376,759,163	34,103	272,748	156,137	14	2	23
1900...	22,380	400,818,214	36,324	290,516	143,288	12	11	23
1901...	26,667	411,919,765	38,015	304,048	123,574	11	4	25
1902...	23,816	442,864,874	39,419	315,284	148,762	13	2	26
1903...	33,530	452,644,207	40,678	325,368	107,998	9	8	13
1904...	37,212	438,606,750	41,827	334,560	94,296	8	11	27

In 1887 about one-half of the wheels used were made in contracting chills.

In 1902, 5,000 common chill wheels were bought.

In 1903, 12,500 common chill wheels were bought.

In 1904, 7,500 common chill wheels were bought.

All other wheels used subsequent to 1887 were made in contracting chills.

STATEMENT SHOWING C. M. & ST. PAUL RY. CAST WHEELS IN PASSENGER SERVICE.

Year.	Passenger. No. of wheels.	Passenger. Average mileage.	Bag. mail and express. No. of wheels.	Bag. mail and express. Average mileage.	Parlor and sleeper. No. of wheels.	Parlor and sleeper. Average mileage.	Total. No. of wheels.	Total. Average mileage.
All Wheels Scrapped Except for Sliding.								
1899...	713	96,741	792	105,672	102	92,827	1,607	100,983
1900...	821	104,740	916	108,956	171	113,316	1,908	107,533
1901...	952	91,533	929	97,563	114	96,115	1,995	94,603
1902...	919	88,674	887	93,530	111	83,097	1,917	90,598
1903...	1,163	88,463	1,215	98,108	141	83,191	2,519	92,820
1904...	1,708	96,770	1,585	100,031	137	100,510	3,430	98,426
All Wheels Scrapped on Account of Sliding.								
1899...	719	44,114	338	52,843	228	29,860	1,285	43,663
1900...	667	39,146	302	48,194	184	41,521	1,153	41,982
1901...	678	41,173	298	48,317	130	40,257	1,106	42,989
1902...	843	40,482	319	48,721	222	34,471	1,384	41,417
1903...	666	45,838	326	51,433	170	37,541	1,162	46,194
1904...	818	42,686	349	42,362	138	33,930	1,305	41,673
All Wheels Scrapped.								
1899...	1,432	70,417	1,130	89,870	330	49,020	2,892	75,577
1900...	1,488	75,404	1,218	93,891	355	76,104	3,061	82,841
1901...	1,630	70,586	1,227	85,602	244	66,353	3,101	76,194
1902...	1,762	65,617	1,206	81,677	333	50,680	3,301	69,978
1903...	1,829	72,942	1,541	88,234	311	58,238	3,681	78,101
1904...	2,526	79,755	1,934	89,625	275	67,099	4,735	82,785

AXLE INSPECTION IN A LATHE.—At the Montreal shops of the Canadian Pacific all driving wheel tires are turned in one 90 in. lathe. After the wheels are set in the machine and the turning begins, a helper paints the axle journals with white lead and oil. The jar of the lathe renders it possible to discover cracks which are not revealed by any other method of inspection.

USE OLD BOILER STEEL.—The blacksmith shop was short of billets. Sets of guides were required for wreck repairs of two engines which were greatly needed on the road. The foreman of the blacksmith shop used old boiler steel. It was piled, heated in an oil furnace, welded and hammered into guides. This mild steel is now giving excellent service in these guides.

ANGUS LOCOMOTIVE SHOPS.

CANADIAN PACIFIC RAILWAY.

VII.

(*For Previous Article See Page* 161.)

A complete list of the machine tools of this shop was presented last month. The output in the month of February was 6 new locomotives, 32 heavy repairs of 100 per cent. engines, that is to say, engines of 20,000 lbs. tractive effort, and light repairs to 18 more. Out of 26 engines in the shops at the time of the writer's visit 17 required heavy fire box work. In the locomotive shop 1,373 men were on the pay roll last March. Of the work of the locomotive shop 50 per cent. of the labor is devoted to repairs, 25 per cent. to the building of new locomotives, 20 per cent. to manufacturing and 5 per cent. to tools and miscellaneous service. The shops were opened last August, and in December, besides the repair, 6 new locomotives were built.

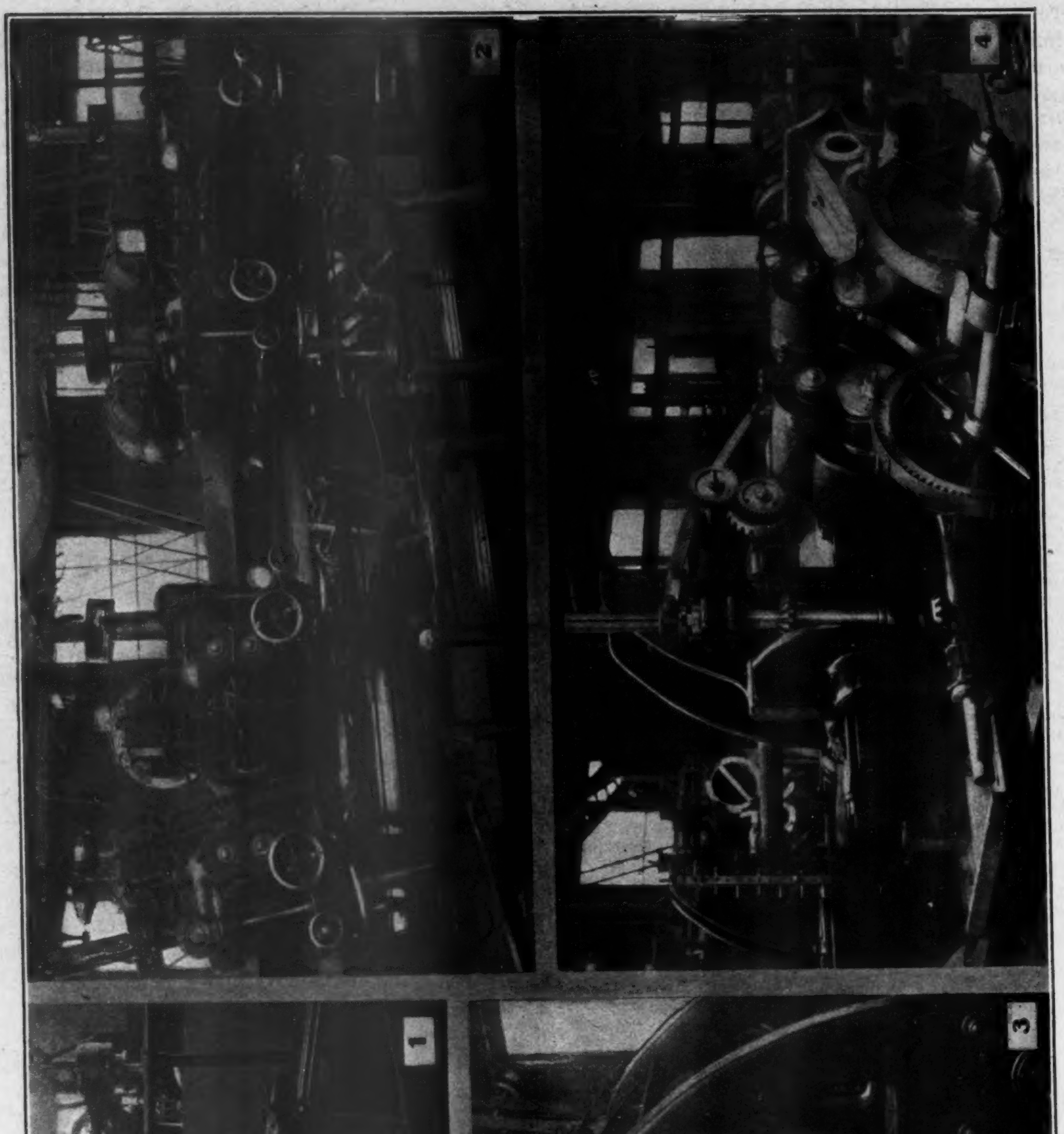
While the standing capacity of the shop is for 36 engines, 26 pits are used for repair work and 3 pits for new construction. There are 5 gangs for the 26 pits, the shop being organized on the travelling gang system. These gangs are arranged as follows:

A stripping gang has 2 pits and is divided into 2 sections of 6 men each; 6 men strip an engine and remove the wheels, the other 6 attend to the steam chests, cylinders and general stripping. These men do all the stripping in the shop and do nothing else. There are 3 general repair gangs for heavy repairs; 1 gang for light repairs and another gang for miscellaneous work, such as steam shovels and rotary snow ploughs. In each of the repair gangs there are 8 fitters, 4 apprentices and 1 helper. The light repair gang attends to such repairs as are made without taking an engine off its wheels. The new engine gang consists of 14 fitters, 2 apprentices, 2 drillers, 2 boys and 1 helper. Floating gangs are arranged as follows:

Three fitters and 1 apprentice attend to all the steam chest and valve gear work except that of new engines. The motion gang consists of 1 fitter and 2 apprentices. The steam pipe gang, 4 fitters and 1 apprentice. Shoes and wedges are attended to by a gang of 4 fitters and 2 apprentices. The brass mounting work is done by 3 fitters and 1 apprentice. One man takes care of all the air pumps and accessories. One man and an apprentice looks after the guides. One man and an apprentice set all the valves in the shop. A gang of 3 fitters and 2 apprentices is responsible for the braking and spring gear. As a general rule, each gang has 6 engines.

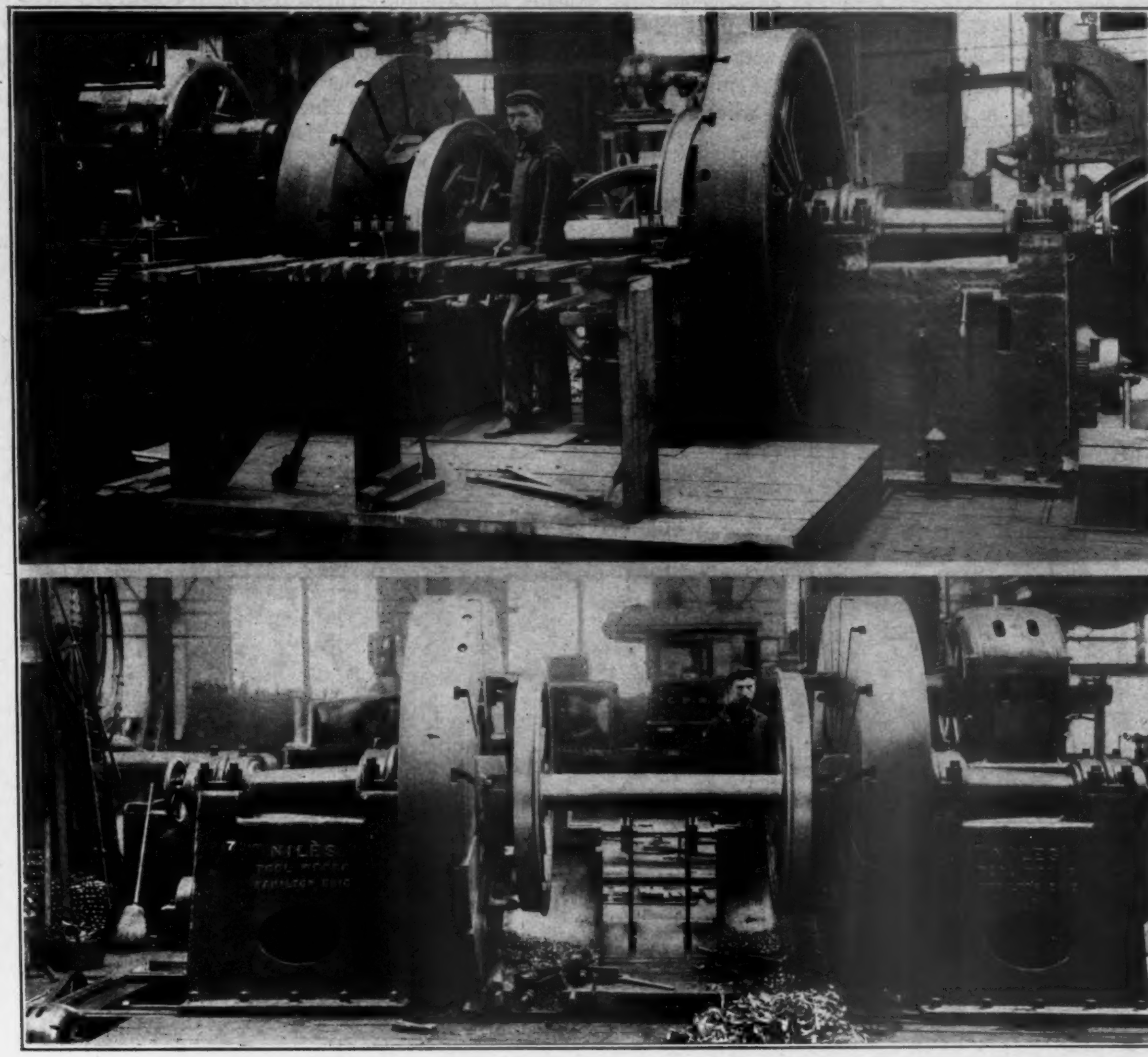
The pace of this shop is a good, healthy one, and blue chips are seen in abundance, in fact more generally than in any railroad shop the writer has visited. The shop management does not aim at record breaking, but rather to attain a good "gait" of the shop and extending even into corners. The erecting shop foreman meets the sub-foremen in his office every morning and shows them the costs of the previous day, the figures being ready for him. Period statements are discussed by the foreman on the 7th, 14th, 21st and last day of the month, or days corresponding nearly to these, the figures being arranged during the week to show the actual cost of the work. A daily progress report is made on each engine and a shop schedule will be introduced in the future. Reasonably cheap rather than very rapid output, a steady business-like pace instead of a variable one, is the object sought. The actual costs are closely watched, in such a way as to inspire the foremen with the importance of the commercial question involved. This shop has a department for providing jigs, templets, and the supply of labor-saving appliances for setting and holding work in the machines surpasses that of many shops which have been running for many years.

Mr. Vaughan's method of keeping locomotive repair records has undoubtedly much to do with the commercial view of the



MACHINERY IN ANGUS SHOPS, CANADIAN PACIFIC RAILWAY.

(1) BARDONS & OLIVER 5-IN. TURRET LATHE.
(2) BEMENT-MILES FRAME DRILLS.
(3) POND DOUBLE HEAD PLANER.
(4) BEMENT-MILES CYLINDER BORER.



90-INCH NILES WHEEL LATHE.—ANGUS SHOPS, CANADIAN PACIFIC RAILWAY.

shop taken by all of the foremen. His article in this number explains this system fully. It seems to lead the road men to measure their work in terms of mileage and the shop men to measure theirs in dollars and cents. Such comments are certainly appropriate in describing these shops, because the completion of the plant itself is considered as only the beginning, and too often a new plant is deficient in organization for a long time after its completion.

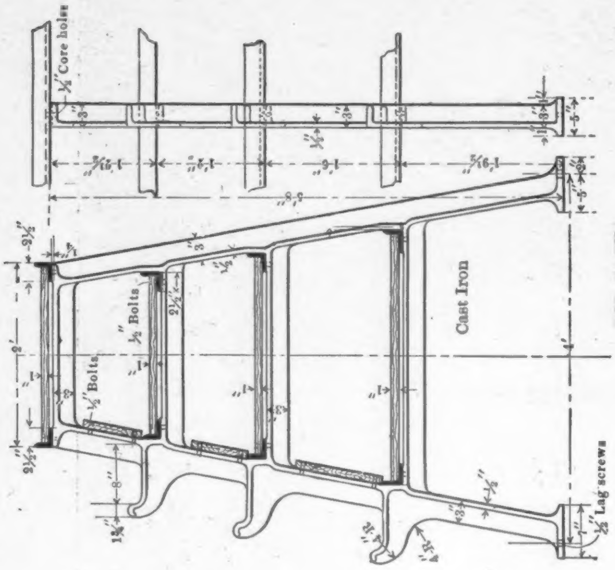
The brass department in the gallery is worthy of more space than can be given here. An example of the work done will suffice to indicate the character of its management. Mud plugs are made in an ordinary Warner and Swasey turret lathe in three sizes from 2½ ins. to 2¾ ins. at the rate of 30 per hour. They are made of brass. A forming tool cuts the taper and the threads are cut by a collapsing die with a taper attachment, this having been developed in this department. There is no difficulty with leaky mud plugs.

The small as well as the large machines throughout this entire shop are running at a pace which gives an impression of activity not too often found in railroad shops.

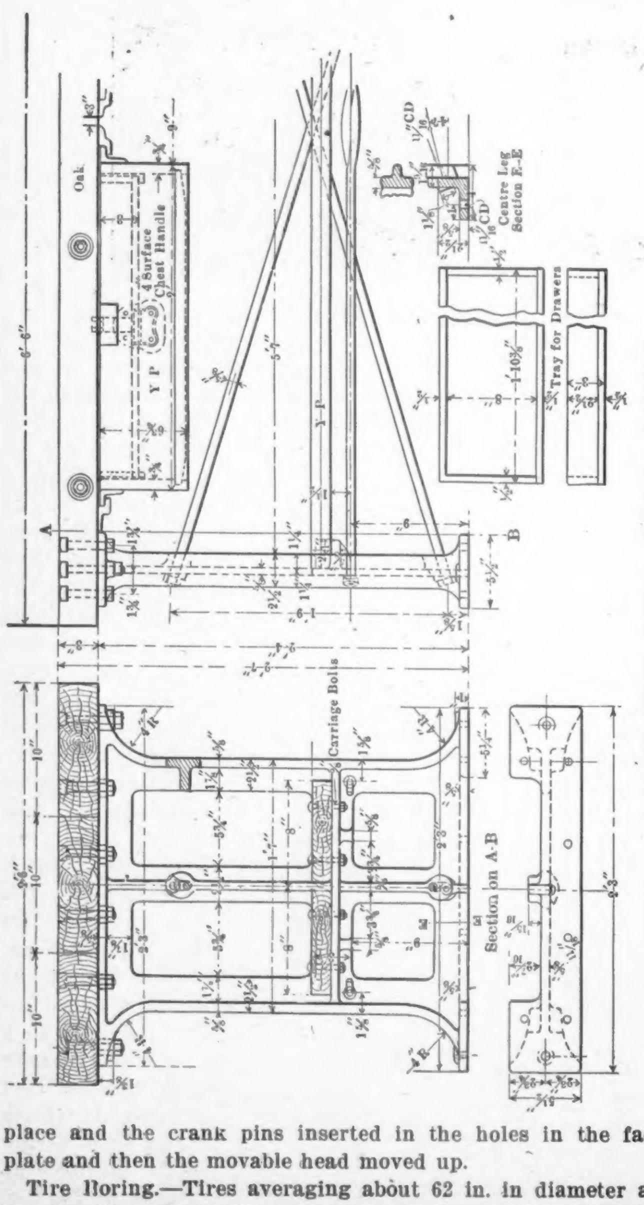
It is the opinion of the writer that a larger proportion of variable speed drives would have been advantageous. As seen in the list of machinery printed last month, the direct current variable speed drives, or independent motors, are confined to a 90-in. mill having three motors; Bement-Miles milling machine; cylinder borer; 60-in. Niles boring mill; locomotive frame drill; double-head shaper and two small boring mills, a total of eight machines. In addition to these the 90-in. Niles wheel lathe, the cylinder planer and three-head slotter have A. C. so-called variable speed motors.

Ninety-Inch Niles Wheel Lathe.—This lathe, driven by a 30-h.p. induction motor and driven by a Morse chain, is supposed to have from 40 to 50 per cent. speed variation in the motor at full load. The actual variation, however, is limited to about 13 per cent. This machine is illustrated in the engraving. The motor is likely to be changed. This machine is capable of maintaining the tires of 700 locomotives and to turn the tires of 5 consolidation engines in 5 days. An average of 6 pairs of 57-in. wheels with Krupp tires have been turned at the rate of 1 hour and 15 minutes per pair for the actual cutting time. Two pairs of 84-in. wheels have been turned in 4 hours and 10 minutes. The secret is that this is a heavy, strong, large-journaled machine, with a total weight of 50 tons, the work being held close to the tool by improved devices. The machine turns out 5 pairs of from 55 to 62-in. tires per day, 2 hours per pair representing the work which it will do regularly. Cutting speeds of about 12 ft. per minute are used, and the machine will take all the cut there is to take on a worn tire at a ¼-in. feed. The machine is designed for taking cuts ½ in. deep, 3-16 in. feed, with a cutting speed up to 30 ft. per minute. The main drive motor is of 30 h.p. capacity, and the motor for traversing the head of 3 h.p. capacity. The face-plates are driven by internal gears, the pinions which drive them being driven by intermediate gears, thus increasing the speed of the main driving shaft. As this driving shaft runs at 3 to 4 times the speed, and is of larger diameter than that usually furnished on driving-wheel lathes, its torsion is therefore very much reduced, making the drive of each face-plate steady under the heaviest cuts. The patented driving dogs permit the full power of the machine to be utilized at the tools allowing as heavy cuts and high speeds to be used as the tool

steel will stand. The photograph shows clearly the application of these dogs. The dogs are arranged at sufficient distance from the face-plates so that all drivers but those having the main crank pin on them can be put in without moving the movable head. On wheels which have the main crank pins, the movable head is traversed out, the wheels put in



ROD RACK.



WORK BENCH USED IN SHOP DEPARTMENTS.

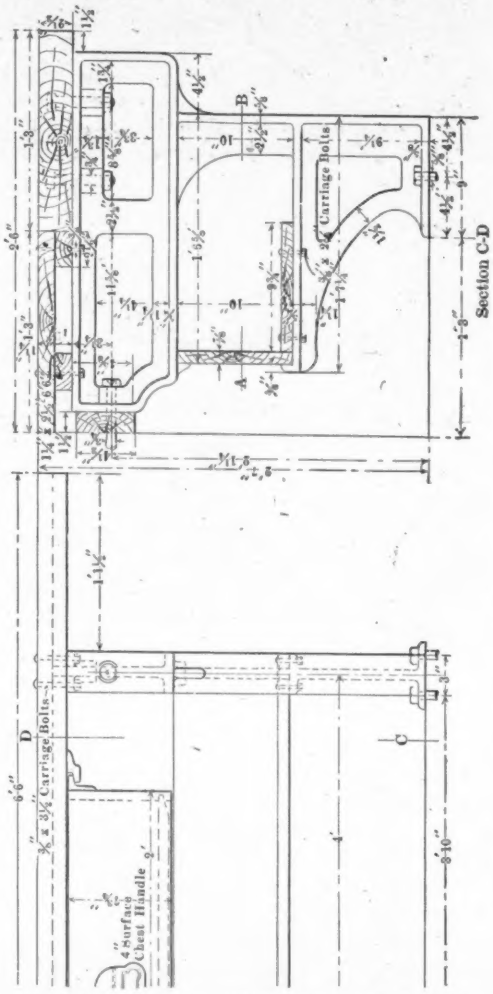
place and the crank pins inserted in the holes in the face-plate and then the movable head moved up.

Tire Boring.—Tires averaging about 62 in. in diameter are bored at the rate of 12 or 13 per day, averaging more than 1 per hour. This is done on an old Craven boring mill, the mill being 20 years old. Thirty-four-in. truck tires with 2 retaining rings are finished at the rate of 11 in 10 hours on two smaller mills, one of the mills being a Bullard and the other a Niles, shown in the list of machinery last month.

Slotting.—An old 12-in. slotter, 22 years old, slots 12 cast iron driving boxes for the brasses per day of 10 hours, the size of the axle being 8½ ins.

Frame Planing.—The Shanks frame planer cuts at 25½ ft. per minute and returns at 52 ft. per minute. A pair of switcher frames are planed on both sides and the top in 19 hours with a ⅝-in. cut and 7-32-in. feed. With one of the new tool steels the tool cuts across the frame with one sharpening.

Frame Slotting.—The Bertram 3-head frame slotter slots 4 switcher frames of cast steel in 50 hours, 4 iron frames are



WORK BENCH FOR SHOPS AND ROUNDHOUSES.—CANADIAN PACIFIC RAILWAY.

slotted in 30 hours. The slotting work is done in about half the time of the planing. The slotter has a stroke of 26 in.

Rod Planing.—A Pond double-head rod planer is equipped with a 15-h.p. motor for the main drive, which is not sufficiently powerful. Four Laird guides, 7 x 2¾ in the rough, are planed at once and finished to 6¼ x 2⅜ in. in four hours.

Shaper.—The 2-head Bertram shaper is driven by a 25-h.p. D. C. variable speed motor with a speed variation of 2 to 1. It cuts ⅝ x 1-16 ins. at 23 ft. per minute on rod work, and this is fairly within the capacity of the machine.

Some of the more interesting of the new machines and their motor drives are illustrated in the accompanying photographs. The work benches of the machine shop and the rod racks referred to in the May number are also illustrated.

The Stolze Gas Turbine.—Dr. Stolze of Berlin has been at work since 1873 upon a gas turbine, and is now building one of 200 h.p. According to the *Engineering Review*, the experimental machine consisted of two separate turbines mounted on a common shaft, one acting as a rotary air compressor and the other being the turbine proper.

INTERNATIONAL RAILWAY CONGRESS, WASHINGTON, D. C.

The seventh meeting of this international association of railway officials was opened May 4 at the New Willard Hotel, Washington, D. C., by an address by the Hon. Charles W. Fairbanks, vice president of the United States. The speaker commented upon the fact that the great development of railroad transportation had been compassed by the lives of many men now living. Beginning locally to serve small needs, it had become the artery of political and commercial affairs of the world. His address was a fitting tribute to transportation as a civilizing, developing, unifying influence, making for universal friendship, fellowship and peace.

Mr. Gerard, president of the permanent commission of the Congress, followed, stating that 70 years ago Belgium opened its first public railway in 1834 (which, by the way, was two years after the AMERICAN ENGINEER was founded). To-day that little country has 4,515 miles of railways, covering a territory of 11,500 square miles, this development, measured by the size of the country being greater than that of any other country in the world. To Belgium also belonged the credit of inaugurating the International Railway Congress. Personifying the traditions of the organization, the speaker thanked the United States for its interest in the organization. From the first meeting Mr. E. T. Jeffrey of the Denver & Rio Grande had attended all conventions of the Congress. Mr. Gerard spoke of the work before the organization consisting of 20 subjects and 47 reports.

Mr. Stuyvesant Fish, president of the Illinois Central Railroad, as president of the American Railway Association, welcomed the Congress to this country for the first time it had ever met outside of Europe. This meeting also was the first to which German government delegates had been sent. Mr. Fish gave a prominent place to John Ericsson in the development of the locomotive and noted that his death occurred as recently as 1889. Great Britain had been the birthplace of railroads, but the United States had brought about their greatest development. In the United States three-quarters of the country depended absolutely upon railroads for its settlement. Mr. Fish presented many important statistics to compare units of service showing what our railroads had accomplished. This interesting address merits more space than may be given to it here.

REPORTS OF THE SECTIONS.

LOCOMOTIVES AND ROLLING STOCK.

Mr. J. E. Muhlfeld, general superintendent of motive power of the Baltimore & Ohio, was the reporter for the United States on this subject which treated of the increase in the power of locomotives by the adoption of high pressures and of the compound principle. The conclusions of his paper were as follows:

1. Locomotives of great power, within the present gauge, clearance and weight limits, may be designed and constructed to remain effective for several years and produce a higher average speed and tractive power with less cost for locomotive expenses per unit of power developed, than that given by locomotives of large capacity in use to-day or from the previous lighter equipment.
2. The efficiency and economy predicted and anticipated from the use of locomotives of great power have not been attained. Their development has been too rapid on the basis of the theoretical calculations which did not include the necessary factors for practical results, and also owing to the disregard of simplicity in design, substantial maintenance and speed as elements of economy.
3. Locomotives of comparatively recent construction have been built without proper consideration for the use of railroad standard designs, specifications, practices and processes which continued and practical experience may have determined to be more suitable and interchangeable than the standards of locomotive builders.
4. The present dead weight should be reduced by the use of design and material which will combine the least weight and greatest desired strength.
5. The elimination of those individual preferences and devices, more or less visionary, which have no real value, by the use of simple, practical design and construction, will produce more satisfactory general results.
6. The motive power department supervision has often been curtailed when extension of organization and direct oversight should have been given to insure the desired performance. Changes in organization and methods have frequently been made in preference to technical education and advancement for the deserving rank and file.
7. The locomotive maintenance and dispatch facilities have not always been developed to meet the proportionate increase in the locomotive dimensions, capacity and requirements, while slow line movement has made it necessary to increase average mileage by reducing delay at terminals during a period when more opportunity for maintenance and handling has been essential.
8. The tonnage hauled per train has frequently precluded the making of an average speed between initial and destination terminals that would be productive of efficiency and economy in locomotive movement.
9. Decreased efficiency has resulted from the irregular transferring and changing of crews of locomotives for long runs. The regular assignment of crews to locomotives and of suitable locomotives to shorter runs on regular districts, should accomplish the best results.
10. Provision for the cleanliness and care of employes and equipment on the line and at terminals, should receive more consideration.
11. Personal supervision and investigation should govern in the construction and operation of locomotives of high power, while statistical information and correspondence should be limited and used with caution.

Mr. J. F. Deems discussed traction increases and mechanical stokers as means for increasing starting power and sustained capacity of locomotives. Other speakers took up the subject of stokers, the conclusion being that they promised good results which would justify careful experimental applications. They had not yet shown a great saving in fuel. Opinions were not unanimously favorable. Compounding received a large share of attention. The speakers clearly indicated the chaotic condition of opinion on this subject which the foreigners could not understand. Mr. Vaughan believed that superheating would give better results than compounding and based his judgment on considerable experience with 2-cylinder compounds and superheaters. Mr. A. Lovell (Santa Fe), who is operating the most powerful compound road locomotives in the world, reported results of tests showing that compounds were more economical in fuel, but slightly less so in maintenance. For heavy fast passenger trains simple engines could not do the work that was done by compounds and for the same work compounds effected savings of 20 to 24 per cent. Furthermore the boilers of simple engines cost more to repair. The increased cost of repairs of compounds was believed to be due solely to their greater power.

Mr. E. Sauvage (Western Railroad of France) presented the conclusion of his report on the same subject from a European point of view, which was briefly summarized as follows:

European designers need to be allowed at least 10 tons per wheel in order to meet the need for more powerful locomotives. He did not find that widening the gauge in Spain, Portugal, Ireland and India showed an increase of power in locomotives. It was not considered desirable to exceed 300 r.p.m. of driving wheels and about 6 ft. 6¾ ins. in diameter. Larger wheels meant heavier engines, and the effect of high rotative speed could be corrected by large ports and piston valves. The use of wide fireboxes extended over the rear wheels was desirable in Atlantic type locomotives. Pressures as high as 228 lbs. per sq. in. were used, but involved increased cost in boiler maintenance. Serve tubes were in general use abroad, but they necessitated frequent cleaning. Compounding had established itself as a factor of economy or increased power for the same consumption of fuel. Four-cylinder compounds had given good results. Two separate valve gears and separation of the cylinder efforts between two axles was preferred. Piston valves were again favorably mentioned. Tail rods were recommended for cylinders 19 ins. in diameter and longer. By use of high pressures and compounding 1,900 h.p. could be obtained within present limits of weight. Eight-coupled locomotives were favorites for freight service, but they are limited to about 22,000 lbs. tractive power because of the weakness of European couplers.

Mr. Moffre (Midi Railway, France,) stated that French engineers strongly favored compounding. Simple engines after being converted into compounds with the same boilers showed an improvement of 20 per cent. in economy of fuel. He believed 4-cylinders to be desirable even if superheating succeeds compounding. Crank axles were not worried about in Europe, where they were making mileages of over 350,000 miles without developing cracks. Mr. Karl Steinbiss (Prussia) stated that 1,000 Von Borries and Mallet compounds were giving good results in that country. An average gain of 10 per cent. in fuel was found and practically no increase in cost of maintenance. Great things were expected from super-

heating. German engines were limited to 8 tons per wheel. Mr. A. W. Gibbs (Pennsylvania) gave excellent reports of the performance of the De Glehn compound on that road. Mr. Laurent (Paris-Orleans Railway) admitted that staybolts were troublesome in France. Manganese bronze substituted for copper was an improvement, but a still better metal was sought. The same trouble had been experienced with American engines in France and was believed to be unavoidable with high pressures. This speaker defended compounds from the charge of lack of flexibility. Within load limits varying 50 per cent. the fuel per unit of work did not vary 5 per cent. (He was speaking of De Glehn compounds with separate valve gears for high and low pressure cylinders.) The foreigners strongly favored compounding and this opinion was shared by Americans who had had the greatest amount of experience with this principle.

In discussing fireboxes Mr. A. W. Gibbs showed that the actual wearing of fireboxes is not as rapid as it is believed to be. With 3,300 locomotives in service, 700 of which were heavy one, not over 70 fireboxes required replacement annually and in a boiler having a life of 20 years fireboxes are usually renewed twice. Bad water and lack of care in construction were believed to be the most frequent causes of boiler defects.

The speakers frequently returned to the subject of compounding. Mr. Wright of the Great Western Railway, England, stated that the De Glehn compound on that road had covered the distance from London to Plymouth, 246 miles, without a stop. He believed that the superiority of that engine was due to its independent mechanisms. That road has ordered two other locomotives of the same type of a greater power.

Mr. M. Ronayme stated that in order to increase the capacity of locomotives on the roads of New Zealand he had ordered four locomotives of the De Glehn type, and from the remarks which he had heard at the Congress he felt sure that he was on the right track. He intended to experiment with spirally corrugated tubes in order to burn lignite fuel. Mr. Tordeux, Eastern Railway of France, stated that his road had 330 4-cylinder balanced compounds. He had had satisfactory experience with piston valves. Mr. D. F. Crawford, Pennsylvania lines, expressed a favorable opinion of piston valves, especially in passenger service.

The discussion was summed up by Mr. Muhlfeld, who stated that boiler pressures are higher in the United States than in Europe, and commented upon the slow adoption of the compound system in America, which he attributed to difficulties encountered at the beginning and to the object aimed at by compounding in this country, which was to increase capacity, whereas in Europe it was to increase economy. The speaker believed that superheating merited more attention in this country than it had received, and he spoke favorably of articulated locomotives. At the close of this discussion the following conclusions were framed and were afterwards adopted at the general meeting.

The power of locomotives is more limited in Europe than in America, owing to the lower allowance of weight per axle.

European engineers generally agree in thinking that compounding admits of the construction of engines giving the maximum power and economy.

This system utilizes the steam very well and does not appear to increase to any noticeable extent the cost of maintenance of locomotives; it does not make the maintenance of the boilers more difficult, but that is due to their increased size and higher working pressure, which are necessary in all cases. Almost all locomotives built in France in recent years have four balanced cylinders. These engines, as well as other compound engines of other systems, are also employed in other European countries, especially Germany, Austria, Spain, etc. Several engineers in Great Britain and Ireland express equal satisfaction from their use and insist on the advantage of separating the high and low pressure machinery. A number of American engineers also express opinions favorable to compound locomotives, which have given satisfactory results on the Atchison, Topeka & Santa Fe Railway; the sentiment on this matter is, however, less unanimous in the United States than in Europe. The section has been informed of experiments made in New Zealand with four-cylinder compound locomotives.

The introduction of American locomotives in Europe and European locomotives in America has had the advantage of making known on both sides some interesting details of construction, particularly the light weight of the parts of European locomotives and the syphon and sight feed lubricators of American locomotives.

The constantly increasing use of cast steel is observed, which in the United States has even been tried for cylinders.

The use of the Walschaerts motion gear is extending in the United States.

Generally speaking, all the engineers who have spoken of cylindrical valve chests appear well satisfied with them.

A number of tests of automatic stokers have been made in the United States and on the Great Western Railway of England, but as yet the results have not been definite. It has also been found, both in America and in England, that without the aid of these devices, but with proper arrangements of grates, the heaviest firing necessary at the present time can be effected without difficulty.

Finally the section has examined the use of articulated locomotives of great power on lines of irregular grades, particularly Mallet locomotives and those designed by the Nord Francais and Nord de l'Espagne railways.

Lighting, Heating and Ventilation.—The reporter of this subject, Dr. C. B. Dudley, of the Pennsylvania Railroad, presented an admirable paper discussing methods of heating, lighting and ventilating passenger trains. He described the systems in use on the Pennsylvania Railroad, which have been thoroughly presented in this journal. Mr. Max Toltz (Manistee & Grand Rapids Railroad), presented an account with figures of experiments with a system designed by Mr. Lipschutz, using compressed acetylene. Mr. W. E. Fowler (Canadian Pacific) confirmed the information given by Mr. Toltz, stating that the system was used on 36 cars on his road with very satisfactory results. The discussion by foreign delegates indicated that the problem of car lighting is generally appreciated, and that marked progress is being made. Mr. Anderson (Government Railroads of India) said that in Oriental countries electric lighting was a necessity in order to reduce heat. On the main lines of India 95 per cent. of the cars are lighted with electricity, either with dynamos at the head end of the train by storage batteries or by the Stone system of lighting from the axle. The high cost of electric lighting was mentioned by a number of speakers. In regard to heating, the information brought out is likely to be of more value to the foreign delegates than to our own. The following conclusions were adopted:

As regards lighting, the Congress notes the development of the use of incandescent mantles, heated by oil gas and sometimes by common gas, and of different systems of electric lighting. Cylindrical mantles seem to be somewhat stronger than globe mantles, but the latter distribute the light somewhat better. Various types of mantles are used in Europe by different managements, especially in France and Germany, and are beginning to extend to the United States.

Systems of electric lighting are giving satisfaction on different roads. Attention is called to their advantage in certain cases for intermittent lighting, in passing through tunnels and operating driving fans.

Acetylene gas has been used mixed with Pintsch gas, especially in France and Germany, but a tendency is observed to abandon this mixture, owing to the use of mantles. On the other hand, mention is made of the use in America of pure compressed acetylene, with some special precautions.

Steam heating has a tendency to extend in different countries. To obtain sufficient heat for very long trains, or in cases of very low temperature, care is taken either to use pipes of sufficient diameter or compressed air mixed with steam.

The adoption of a uniform coupling for all the cars in the same territory is an important question to be solved.

The Congress notes the different systems of car ventilation that have been applied, especially that in use on the Pennsylvania Railroad.

Light Railways.—After a long discussion the section dealing with this subject adopted the following conclusions:

Light railways merit in the highest degree the attention of public authorities. Their construction makes it possible to encourage the progress and development of districts which previously have remained in the background, and it is accordingly not only the interest but the duty of the governments to assist them. It is desirable therefore not to adhere to old types and old methods of construction, operation and regulation, but to introduce every facility possible, adaptable to local needs and available resources. It is also desirable that state governments and local authorities should accord to light railways, either under the form of subsidies, relaxation of requirements or other methods of assistance, the support which they need, both for construction and for operation, so that all parts of the country may be adequately served. When the authorities of a country do not themselves construct or work light railways, and turn them over to private companies, it is indispensable that the terms of the concession should be so defined as to harmonize the interests of the working company with those of the public.

Improved Frogs.—The following conclusions were adopted:

That on all main lines carrying heavy traffic with axle loadings on the locomotive of over 50,000 pounds, and with loads on the

rolling stock reaching as high as 40,080 pounds per axle, the "spring rail frog" or the "hinged spring frog" may be used with perfect safety, where the traffic on the side tracks connecting with the main track is very slight compared with the main traffic.
where the space for crossing from one track to another is limited.

That the "moveable point frogs" may be used at all termini but that where space permits, and where high speed is necessary, a series of switches, with the best designed switches and fixed frogs are preferable.

AUTOMATIC BLOCK SIGNALS.—After an intensely interesting discussion based upon wide experience of American railroads in automatic signals and the favorable opinion from Sir Charles Owen, of the London & Southwestern Railroad, the following conclusions were adopted:

That automatic signaling properly designed and installed be recognized as a suitable means of protecting train and switching movements.

And notes that there has been much improvement and extension of the automatic signaling since the last Congress, and that those who have used it have found it effective for their purpose.

The Section is not prepared to recommend automatic block signaling for general adoption to supersede existing systems, but they consider there are many cases where it has special advantages.

POOLING LOCOMOTIVES.—This subject was reported upon by Mr. G. W. Rhodes for the United States and Mr. Hubert and Mr. Boell for foreign railways. While the discussion drifted into considerable detail, very little was said which can help the United States in its problem. It was evident that the speakers desired to retain individual responsibility of the enginemen and at the same time secure proper mileage from the locomotives. The following conclusions were accepted:

The Congress finds that in Europe and in countries other than North America the general sentiment is very much in favor of the single crew system and unfavorable to complete pooling, which is only used when necessitated by a sudden increase in traffic. However, for certain services various combinations of double or multiple crews or of mixed crews are used according to circumstances.

In North America pooling is, on the contrary, very general, though little used for passenger service, and a tendency to using single crews is generally manifest.

It is, however, in place to remark that the organization of train service depends to a large extent on local conditions.

AUTOMOBILE CARS.—As a result of the discussion of this subject in several sections the following conclusions were adopted:

The simplification of the service on lines which carry little traffic has a general interest for all railways operating such lines. The Congress expresses the wish that the present tendency of a legislation to establish more liberal regulations for lines with little traffic and light trains may become more general, and that the efforts of the managements to equip their light traffic lines with a more economical organization, which promise to give remarkable results, be continued. The simplifications introduced in maintenance of way, stations and trains, as well as the introduction of automotor cars on different lines, merit commendation.

While recognizing that the technical side of the question of automotors, as applied up to the present time, are capable of improvement, the Congress expresses the opinion that experiments with this method of transportation should be continued.

It is desirable that this important question should not be lost sight of and that the International Commission should incorporate it in their programme for the next meeting.

Experiments with automobile cars and with automotors hauling trailers have been numerous during the last few years to an important extent, both for use on lines with little traffic and for use on busy lines, and it may be expected that from now on these cars will constitute a valuable means of transportation, which on some lines will have a great future.

It does not appear doubtful that, owing to the saving of an employe in the driving, to the material reduction in the cost of traction, to the probable reduction in the cost of maintenance, to a better utilization of the rolling stock, to the smaller extent of station installations required, perhaps also owing to less wear of the rails, automobile and automotor cars will make it possible materially to reduce the cost of working lines with little traffic and will in the cases of other lines result in a material improvement in the working of some classes of service. Their use will certainly effect a change in the system of operation in the case of a great number of lines and appears to have a real future before it.

The period of actual operation has, however, only just begun, and definite economic results cannot yet be clearly discerned in favor of a given type of motor or of a given system of working.

It is desirable that railway managements should continue their experiments in this direction and more especially investigate the classes of service to which this new motor is suitable, and the advantages it offers the public and the railway managements, particularly in the matter of cost.

Finally, it is important that any changes recognized or which may be hereafter recognized, as likely to facilitate the advantageous use of automobile and automotor cars should be introduced into the regulations in force.

ELECTRIC TRACTION.—The discussions on three elaborate papers on this subject brought out many interesting facts of experience, including figures of cost and opinions concerning various systems including single phase. The most important feature of the discussion was the expression from Mr. J. A. F. Aspinall, general manager of the Lancashire & Yorkshire Railway, based upon the experience of the electric line between Liverpool and Southport. He stated that electric traction was not adopted by that line to save money, but to make money. In twelve months of service the results have been very satisfactory as to increase in traffic, but the operation is more expensive than with steam. While the cost of coal per ton mile is greater, running expenses are less because of greater mileage by the crews. One reason for adopting electricity was to increase the capacity of the Liverpool terminus. For steam four switch and eight signal operations were required for each train, which were reduced by electricity to two switching movements and four signal operations. Electric traction costs more than steam, but judging from Mr. Aspinall's remarks, the gain in traffic more than compensated for the increased investment. The foreign delegates presented valuable experience in the operation of a number of lines of comparatively heavy service.

The Congress closed on May 14 after the most successful meeting in its history.

TEST OF THE NEW YORK CENTRAL ELECTRIC LOCOMOTIVE.

On April 29 an informal test was made on the experimental track at Schenectady in the presence of Mr. W. J. Wilgus, vice president, and Mr. E. B. Katte, electrical engineer, of the New York Central, and Messrs. E. W. Rice, Jr., W. B. Potter and A. F. Batchelder, of the General Electric Company, to ascertain the relative acceleration and speed characteristics of the electric locomotive 6000 and Pacific type locomotive 2797. The test took place between 8 a. m. and 1 p. m.; the temperature averaged about 50 deg. Fahr.; the weather was cloudy but no rain fell and the rails were dry.

The experimental track is six miles in length, has 80-lb. steel rails with 6 bolt 36-in. splices, 16 yellow pine ties to the 30-ft. rail, gravel ballast well surfaced and curves elevated for a speed of about 70 miles per hour. Starting from mile post 162, where the experimental track begins, the grades in a westerly direction are as follows: Rising grades of 0.11 for about ½ mile; 0.13 for 1.84 miles; 0.07 for 1.04 miles; 0.20 for 0.38 mile; 0.32 for 0.28 mile; 0.14 for ½ mile, and down grades of 0.12 for 1.09 miles and 0.35 for about .4 mile. There are seven curves varying from 0 deg. 48 min. to 2 deg. 17 min., the maximum length of tangent being 7,565 ft. between mile posts 163 and 165.

The working conductor consists of a top-contact 70-lb. steel rail reinforced with copper and covered in part with a board protection. At four crossings overhead construction is used to cover gaps where the use of the third rail is inadmissible. Experiments are about to be started with a new type of under-contact rail which it is believed will cure many of the evils of the ordinary top-contact third rail.

The total weight of the electric locomotive is 200,500 lbs. and that of the steam locomotive and tender is 342,000 lbs. The 8-car electric train, including the locomotive, weighed 513.6 tons, while the 8-car steam train, including the weight of the locomotive and tender, weighed 513 tons. The 6-car electric train weighed 407.5 tons and the steam train 427 tons, the weight of the locomotive being included in both cases.

The average voltages during acceleration were as follows:

Runs.	Series.	Series-Multiple.	Multiple.
A	520	540	325
B	620	520	275
C	600	540	330
D	680	680	515
E	650	600	420
F	600	620	455

Due to the restricted cross-section of conductors the voltages dropped during acceleration considerably lower than will obtain in actual practice within the electric zone in the vicinity of New York, and the results obtained in this comparative

test are much less favorable for the electric locomotive than will be secured in actual practice.

RUN A.—Both 8-car trains started together with the steam locomotive accelerating faster than the electric locomotive, due to the abnormal drop in voltage from the pressure at the station of 700 volts to a track voltage as low as 325 volts. At 3,000 ft. from the starting point the electric locomotive gained the same speed as the steam locomotive, and from that point accelerated more rapidly, so that at a distance of 2 miles from the starting point the electric locomotive passed the steam locomotive, and at the shutting off point was two train lengths ahead. The maximum speed of the steam locomotive was 50 m.p.h., while that of the electric locomotive was 57 m.p.h.

RUN B.—This run was made under the same conditions as run A with results practically the same, except that the speeds were higher, as follows: Maximum speed of steam locomotive, 53.6 m.p.h.; electric locomotive, 60 m.p.h.

RUN C.—This run was made with the 6-car trains and owing to the very low voltage which during acceleration fell as low as 330 volts, at first the steam locomotive accelerated more rapidly, but at the end of about a mile the electric locomotive overtook the steam train and continued to forge ahead until the power was shut off. Maximum speed of electric locomotive, 61.6 m.p.h.; steam locomotive, 58 m.p.h.

RUN D.—In order to secure as nearly as possible results comparable with the conditions of voltage that will obtain in the actual operating zone, this run with the 6-car trains similar to those used in run C, was started at a point nearer the sub-station, near mile post 164. For this run the electric locomotive from the first turn of the wheels accelerated faster than the steam locomotive and at a distance of 1,500 feet from the starting point the electric locomotive led by a train length.

RUN E.—This run was made with the electric locomotive and one coach, a maximum speed of 79 m.p.h. being attained.

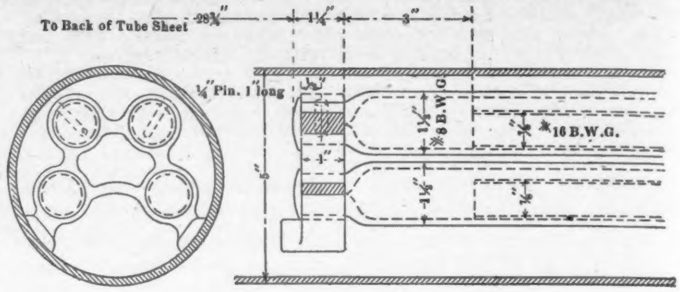
RUN F.—This run was made with the electric locomotive running light and with the power shut off on curves, a maximum speed of 80.2 m.p.h. being attained. (Speed test on May 1 reached 85 m.p.h. with a limitation on the 2 deg. 17 min. curve of 78 m.p.h.)

At all speeds the smooth riding qualities of the electric locomotive were very noticeable, especially the lack of nosing effects. After the runs the track was carefully examined and no tendency to spread rails was discovered. However, on the sharper curves the high speeds caused the track to shift bodily on the ballast, due to insufficient super-elevation of the outer rail. The most important test is run D, as the voltage during that test more nearly approached the conditions that will be obtained in the electric zone. Therefore the following comparison of the steam and electric locomotives based upon the results of this run are very interesting as illustrating the marked superiority in the acceleration of the electric locomotive over the steam locomotive, considering the fact that the Pacific type of steam locomotive has practically the same weight upon the drivers.

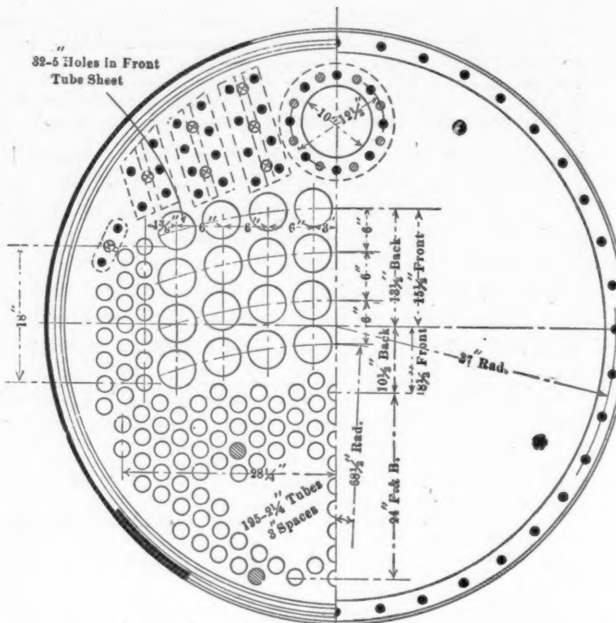
	Steam.	Electric.	Difference in favor of Electric.
Length over all, ft. and ins.	67 7¾	36 11¼	30 8½
Total weight (including tender for steam locomotive), lbs.	342,000	200,500	141,500
Concentrated weight on each driving axle, lbs.	47,000	35,500	11,500
Revenue bearing load back of locomotive, tons	256	307.25	51.25
Acceleration M. P. H. P. S. average up to 50 M. P. H.	.246	.394	.148
Time required to reach speed of 50 M. P. H., seconds	203	127	76

We are indebted for this information to Mr. Edwin B. Katte, electrical engineer of the N. Y. C. & H. R. R. R.

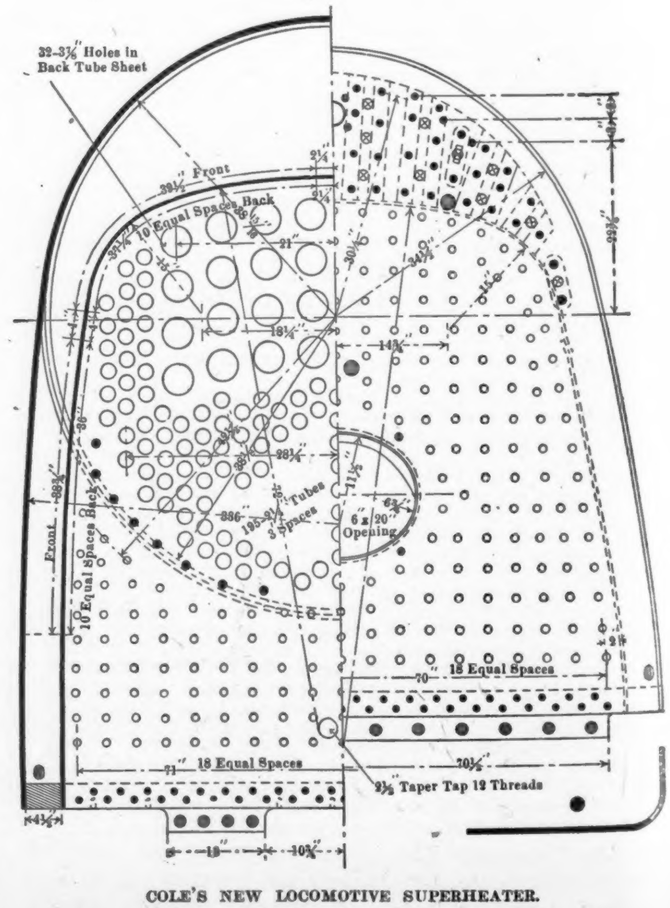
FAST PASSENGER RUN.—On May 14th, a special train of 3 coaches weighing 233 tons, made the run from Philadelphia to Atlantic City over the Atlantic City Railroad, a distance of 55½ miles, at an average speed of 74.8 m. p. h. The return run was made at the rate of 78.3 m. p. h. with two coaches.



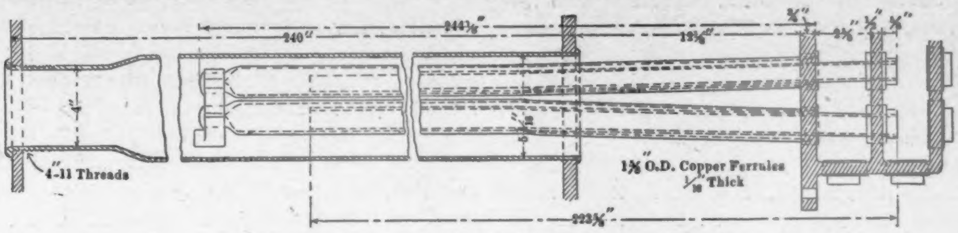
SUPPORTS FOR SUPERHEATER TUBES.



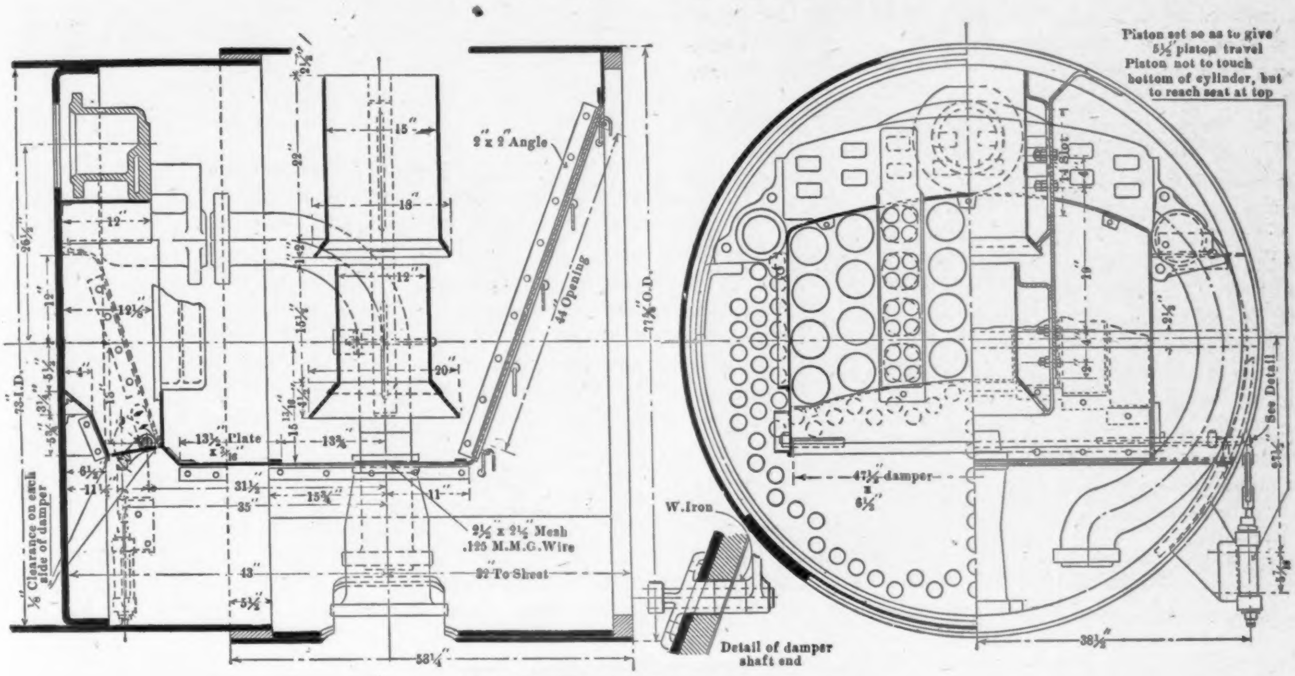
FRONT TUBE SHEET.



COLE'S NEW LOCOMOTIVE SUPERHEATER.



SHOWING ARRANGEMENT OF SUPERHEATER TUBES.



COLE'S NEW LOCOMOTIVE SUPERHEATER.

ERIE PACIFIC TYPE LOCOMOTIVE, WITH SUPERHEATER.

This is the heaviest locomotive of its type. Last month, on page 172, a photograph and table of leading dimensions was presented, and as the superheater, applied to two of three locomotives of this class now running, is specially interesting, because of its large capacity (763 sq. ft.), it is illustrated in detail.

The superheater tubes are contained in 32 large flues 5 ins. in outside diameter swaged down to 4 ins. in diameter at the back tube sheet and enlarged to 5 1-16 ins. in diameter at the front tube sheet. The superheater tubes are in four sets, extending to within about 30 ins. of the back tube sheet. The outer tubes are 1½ ins. outside diameter and of 8 B. W. G. They are secured to malleable iron saddles, which are seated in the large tube, the construction being shown in the engravings. The ends of the outer tubes are forged down and closed by welding to fit these castings. The inner superheater tubes are of pipe ⅞ in. outside diameter and No. 16 B. W. G. It will be observed that this arrangement differs from that previously used by Mr. Cole, although the principle is unchanged. The engravings show the headers, the groups of tubes and the arrangement of the front end.

References to previous articles on locomotive superheaters appear in this journal as follows: The Schmidt smokebox superheater, November, 1902, page 340; Schmidt fire tube superheater, September, 1903, page 317; Cole superheater, September, 1904, page 338, and December, 1904, page 456.

By comparison of these drawings the improvement by Mr. Cole, whereby he greatly increases the heating surface of the superheater in the case of the Erie locomotive, will be at once apparent.

These locomotives are actually hauling 600-ton trains from Jersey City to Port Jervis, 87 miles, in 130 minutes, over a hilly road. From Jersey City to Paterson, 16 miles, there are 2½ miles of grade at 27.6 per mile. From Paterson to Sterlington there are 8 miles ranging from 29 to 57 ft. per mile. From Sterlington to Chester there are 16 miles of up grade varying from 12 to 47 ft. per mile, with 5 miles of down grade before reaching Chester. From Chester to Otisville the first 8 miles are undulating, and 14 miles are up grade, varying from about 26 ft. to 60 ft. per mile, the average grade for this distance being about 1 per cent. At Middletown, 66¼ miles from Jersey City, a stop is made on a grade of about 25 ft. per mile, which is a very difficult starting point for a train. The train hauled by engine No. 2512 on April 24th was started without taking slack. The highest point reached on the division between Jersey City and Port Jervis is near Otisville, and at an elevation of 899.5 ft. above mean low water. From Otisville to Port Jervis the grade is downward for 11 miles, and Port Jervis is 432 ft. higher than the Jersey City terminal. The total length of this engine from the pilot coupler to the tender coupler is 78 ft. 5 ins., and is believed to be the longest passenger locomotive. The leading dimensions were printed last month. The tender provides for 8,500 gals. of water and 16 tons of coal. It has been predicted that no passenger locomotive could be built to perform this service, but on the date referred to it was done with ease by one of these locomotives without a superheater.

RAILROAD REPAIR SHOP MACHINERY.

The suggestion made by Mr. M. K. Barnum in his paper on "A Plan for Maintaining Railroad Repair Shop Machinery," read before the Western Railway Club and reprinted on page 133 of our April journal, that each railway shop establish a machinery depreciation fund for maintaining the machinery in a high state of efficiency by making a yearly allowance of 5 per cent of its value, met with the hearty approval of the members of the club. The suggestion was made during the discussion that in addition to the 5 per cent. to replace old tools, a yearly allowance of about 2 per cent. be made to provide for improved facilities and increased output.

That motive power officials are becoming impressed with the importance of the matter of production improvements is shown by the way in which the discussion shifted to that phase of the question. Mr. Harrington Emerson stated that, "except increase of profitable traffic and economical purchase, use and handling of stores and materials, there is nothing in railroad operation that will so immediately yield large gains as perfect control of shop and repair details, bringing methods first, machines next and men finally up to a high degree of efficiency." He also said that improved tool holders have reduced the value of alloy steels on a single lathe from $117 to $23, and that in their small tools and steels, with a better and larger supply of tools and steels, savings of nearly $3,000 a month had been brought about.

Mr. W. G. Symons called attention to a shop which gave an increased output per month from 57 to 71 per cent. and a decreased cost per engine of from 14 to 26 per cent., these results being largely due to the introduction of the premium plan among the shopmen. Mr. H. T. Bentley stated that in a certain shop, by improving the organization and methods, adding new tools which were carefully selected, and speeding up all around, a schedule of 22 days was made for work which formerly took 60 days. Mr. J. A. Carney spoke of a shop where the output had been increased over 100 per cent. by the addition of a few tools and modern appliances.

VERTICAL MILLING MACHINES IN RAILROAD SHOPS.

Some idea of the great variety of work which may be done to advantage on a vertical milling machine, and the economies which may be effected by its use, may be gained from the accompanying illustrations, which show a few examples of work done on these machines in railroad shops. At the Concord shops of the Boston & Maine Railroad all rod brasses, rod keys, key guards and shims are finished on one of these machines with a considerable saving of time over the old method of planing. A cast iron frame has recently been rigged up for accurately milling the teeth in the reverse lever and throttle lever quadrants. The quadrant with radial arms at the ends makes a sector swinging on a fixed center, and this, by means of a stop pin and rack, is allowed a movement equal to the pitch of the tooth. The time for machining one of these quadrants is very much less with this arrangement than when the work was done on a shaper. On page 32 of our January journal several operations are cited, which were formerly done on slotting machines at the Havelock shops of the Burlington & Missouri River Railroad, but which are now done on a vertical milling machine at a greatly reduced cost.

A general view of one of these machines is shown in Fig. 1. Figs. 2 to 6 illustrate the various operations which cover the entire process of finishing a connecting rod brass at the Concord shops on a Becker-Brainerd miller without the use of special gang cutters. In the first operation, shown in Fig. 2, an inserted tooth face mill is used for facing the bottoms of the 5 brasses. The table is fed at the rate of 7 ins. per minute, and a very smooth and accurate finish is obtained. The work is so clamped that changes may readily be made to facilitate finishing the other surfaces. The second operation shown in Fig. 3 consists in finishing the inner sides of the lower flanges. An inserted tooth cutter is used, and the table is fed at the rate of 3½ ins. per minute. The upper flanges are finished at the same setting by changing the cutter, which requires but a moment. In finishing the sides of the brasses (Fig. 4) the same mill is used as in Fig. 2, but it is fed at a somewhat slower rate. But a short time is required to loosen the

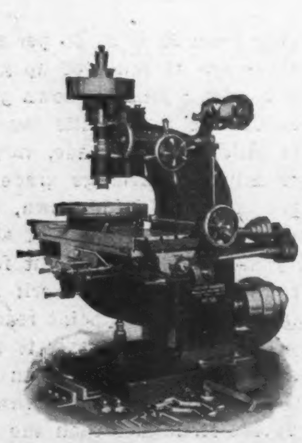


FIG. 1.

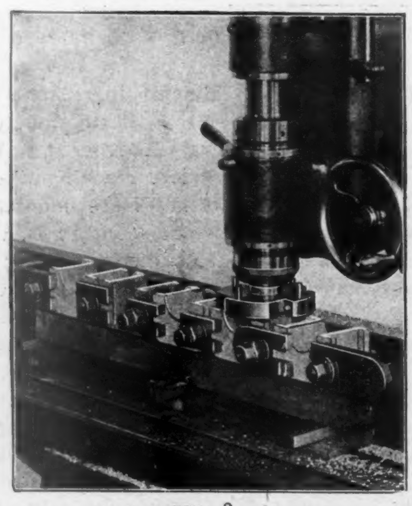


FIG. 2.

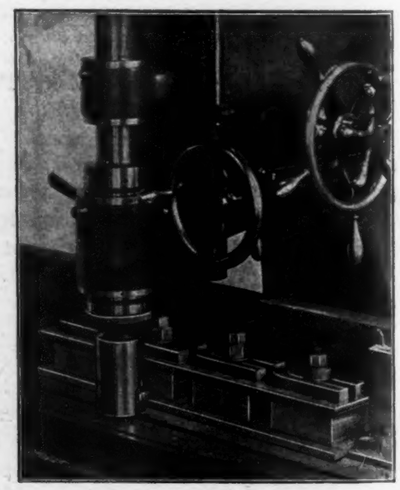


FIG. 3.

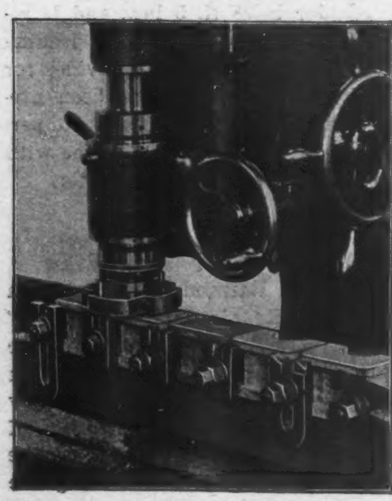


FIG. 4.

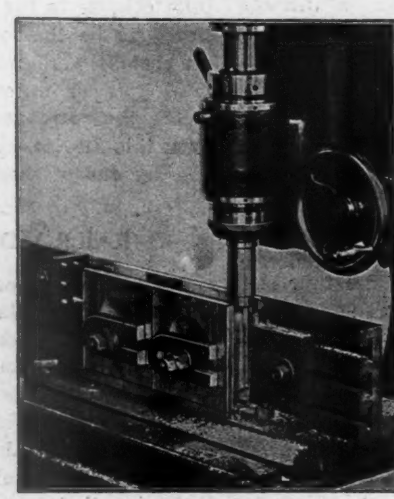


FIG. 5.

FIG. 6.

FINISHING A CONNECTING ROD BRASS ON A VERTICAL MILLING MACHINE AT THE CONCORD SHOPS.

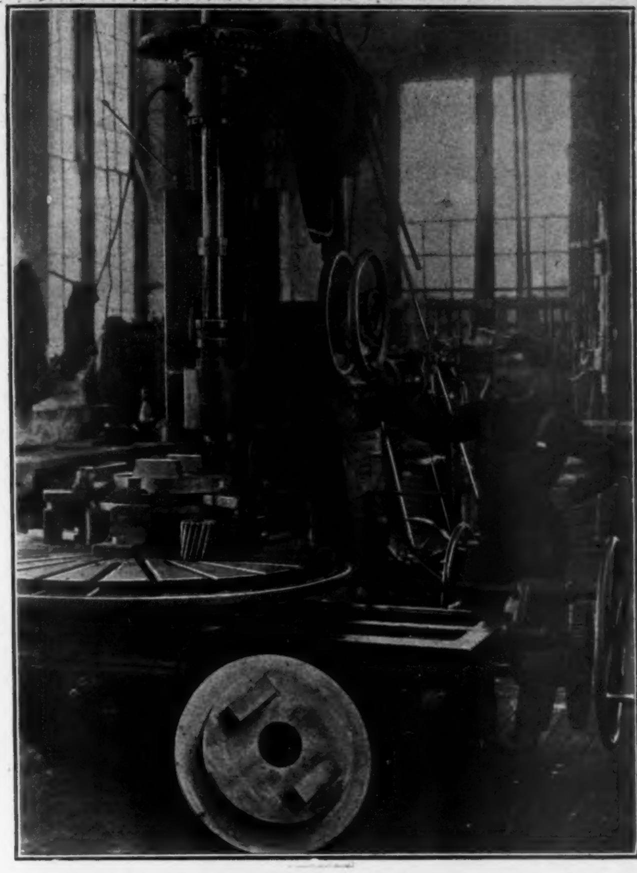


FIG. 7—MILLING BACK CYLINDER HEAD.

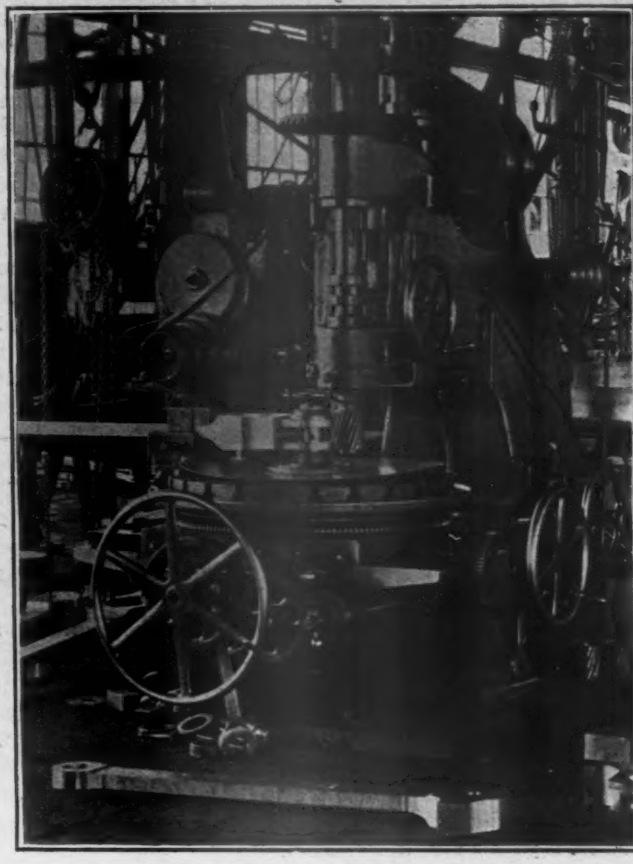


FIG. 8—MILLING SIDE ROD ENDS.

clamps, reverse them, reclamp them and finish the other side with the same tool. The bottom of the recess (Fig. 5) is finished with an inserted tooth cutter in 2 cuts per side, each at the rate of 14 ins. per minute. The tops of the flanges are finished in separate cuts at the same rate of feed. Fig. 6 illustrates the final operation by which the side of the box and the fillet are finished at the same operation by means of a round-nosed mill. For this purpose the rotary table is employed, and great accuracy of finish is obtained.

Fig. 7 shows a back cylinder head being finished on a Bement-Miles vertical milling machine in another shop. One of the finished cylinder heads is shown in the foreground. This work was formerly done on a planer, but because of the lugs to which the guides are bolted it was necessary to plane the piece in two directions. This gave a poor finish, and the time required was about five hours for the head of a 25-in. cylinder. On the vertical milling machine two cutters are used, one for finishing the horizontal surface and the bevel cutter for giving the required angles to the lugs. By this means the head for a 25-in. cylinder may be finished in 2½ hours, and with a very much better finish than formerly obtained. At the Schenectady works of the American Locomotive Company the ends of the side rods are finished on vertical milling machines. Fig. 8 shows a Niles-Bement-Pond machine rounding off the large end of a side rod. This work was formerly done on slotters at a much greater cost.

PERFORMANCE OF MALLET COMPOUND LOCOMOTIVE.

BALTIMORE & OHIO RAILROAD.

The Mallet articulated duplex compound locomotive, No. 2400, which is the largest locomotive that has been built, was completed about one year ago, and exhibited at the Louisiana Purchase Exposition at St. Louis. Mr. J. E. Muhlfeld, general superintendent of motive power of the Baltimore & Ohio, sends the following information concerning its performance:

After the closing of that exhibition the locomotive was brought to the Connellsville division of the Baltimore & Ohio Railroad, and put into regular service on January 6th, 1905, to assist heavy freight trains over the mountain. This locomotive has made several road trips and been in mountain helper service during the past four months, and in this time it has made about 13,500 miles.

The locomotive was designed for the purpose of balancing the power on the division, and to reduce the number of locomotives and crews required to handle heavy freight tonnage over the mountain districts. In order to develop a locomotive of exceptional tractive power to be used for this class of work on a mountain line having considerable curvature and heavy gradients, it was necessary to provide for the maximum adhesion distributed over a short rigid and long flexible wheel base.

The total weight, which is all carried on the driving wheels, which are 57 ins. in diameter, is 334,500 lbs. when the locomotive is in working order. Including the tender, which has a capacity of 15 tons of coal and 7,000 gals. of water, the total weight is 479,500 lbs., or about 193,500 lbs. less than the combined total weight of two of the heaviest consolidation locomotives that are used for through freight service over this same mountain district.

While the draw bar pull behind the tender of two of the consolidation locomotives is about 79,400 lbs., the draw bar pull of No. 2400 is about 74,000 when working compound, and 84,000 lbs. when working simple. The weight of train that can be taken up the mountain by two of the consolidation locomotives is about 2,025 tons contained in loaded steel cars of 100,000 lbs. capacity. The weight of train that No. 2400 and one of the consolidation locomotives can take up the grade is about 3,210 tons contained in similar cars. The above figures are based on the locomotives operating at a speed of ten miles per hour under fair coal and weather conditions, and with No. 2400 working in compound gear.

From the results of the practical performance during the past four months it has been demonstrated that the various special features which are combined in this design will give satisfactory results from an operating standpoint. The use of the articulated feature, as well as of the duplex compound system, with its intercepting valve and simpling gear devices,

Walschaert valve gear, combination hand and power reversing gear, and flexible intermediate receiver and exhaust pipes, have resulted in no embarrassment whatever. The curving and tracking qualities, when the locomotive is going ahead or backing up, have been satisfactory, and there has been very little flange wear, although all driving wheels are equipped with flanged tires. The steaming capacity of the boiler, working of all frictional parts, cylinder packing, piston and slide valves, and the other features that go to make up the requirements for maximum hauling capacity, have been very satisfactory.

While the 2¼-in. tubes in the boiler of this locomotive are 21 ft. in length, practically no difficulty has been experienced due to choking, or on acount of tube, firebox or staybolt leakage. Furthermore, there has been no trouble on acount of priming or lubrication. While it has been noted that quite a number of changes in the minor deails would be desirable, should other locomotives of this type be constructed, still, when taken as a whole, the design, construction and operation can be considered as satisfactory. With respect to the maintenance, this is an item that remains for the future performance to determine, but from present indications, the cost per ton mile will be no greater than that for ordinary consolidation types of helper locomotives.

When operating over combination level and mountain divisions, No. 2400 will consume less coal per ton mile than the various types of simple consolidation locomotives now in the service, and when operated on comparatively level lines, it consumes materially less coal per ton mile. On the mountainous part of the division, the fuel consumption per ton mile is more favorable than for the simple consolidation locomotives, but not to such a great extent as when working on the more level portions of the division.

In averaging up the performance of several through freight trips made during the month of January, 1905, over the division between Connellsville and Rockwood and Connellsville and Sand Patch, these through freight runs being from 44 to 60 miles in length, the following data were recorded:

Running time	5 hrs. 29 mins.
Time lost by stops	3 hrs. 38 mins.
Total time of trip	9 hrs. 7 mins.
Speed while running, miles per hour	9.7
Temperature of atmosphere	33 deg. F.
Temperature of feed water	33 deg. F.
Kind of coal used	Bituminous, about 40 per cent. volatile, run-of-mine grade
Pounds of coal used per trip	24,900
Pounds of coal consumed per sq. ft. of grate area per hour	61.8
Pounds of coal consumed per mile run	472
Pounds of coal consumed per 1,000-ton miles	215
Number of loaded cars hauled	34
Number of empty cars hauled	None
Gross tonnage per train (in tons of 2,000 lbs.)	2,193
Maximum boiler pressure	230 lbs.
Minimum boiler pressure	202 lbs.
Average boiler pressure	220 lbs.
Pounds of water evaporated per lb. of coal	6.4
Pounds of water evaporated per lb. of coal from and at 212 deg. F.	7.9
Minimum gradient on line	level
Maximum gradient on line	1 per cent.
Average gradient on line	.5 per cent.

On the 1 per cent. grade, which is 6½ miles in length, No. 2400 was assisted by one of the regular consolidation type locomotives. On all other portions of the line, where the gradients range from 1 per cent. for a distance of 1 mile, .75 per cent. for a distance of 5 miles, .68 per cent. for a distance of 2 miles, and other grades average from .3 per cent. to .5 per cent., No. 2400 handled the train alone.

The performance of this locomotive for 24 consecutive trips helping trains and operating over a total distance of 14.8 miles up the mountain, the first 8.3 miles of gradient ranging from .2 per cent. to .5 per cent, and the remaining 6.5 miles being 1 per cent., averaged as follows:

Running time	1 hr. 45 mins.
Time lost by stops	2 hrs. 16 mins.
Total time of trip	4 hrs. 1 min.
Speed while running, miles per hour	9.1
Temperature of atmosphere	17 deg. F.
Temperature of feed water	33 deg. F.
Kind of coal used	Bituminous, about 20 per cent. volatile, run-of-mine grade.
Lbs. of coal consumed per trip	8,225
Lbs. of coal consumed per sq. ft. of grate area per hour	66
Lbs. of coal consumed per 1,000-ton miles	303.5
Number of loaded cars per train	39
Number of empty cars per train	None
Gross tonnage per train (in tons of 2,000 lbs.)	2,049
Maximum boiler pressure	230 lbs.
Minimum boiler pressure	188 lbs.
Average boiler pressure	218 lbs.
Lbs. of water evaporated per lb. of coal	5.4
Lbs. of water evaporated from and at 212 deg. F. per lb. of coal	6.7
Total amount of water used while running	39,142 lbs.
Total amount of water used during stops	6,652 lbs.
Total amount of water used during trip	45,794 lbs.
Per cent. of total amount of water used while locomotive was standing	14.5 per cent.

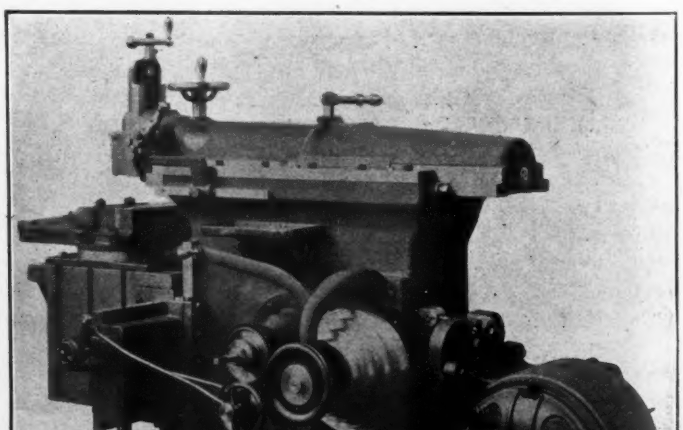
One engineer and one fireman were used on all of these tests to operate the locomotive during each trip. During these tests there were no firebox, boiler tube, or other water or steam leaks around the boiler or machinery of the locomotive, and the waste was that relieved through the pop valves, from injector overflow, on account of condensation, using heaters on injectors, and other similar causes resulting during winter weather and freezing conditions. There were no failures or delays on account of locomotive, except for fire cleaning, and which work was performed at the termination of the run.

In mountain helper service locomotives are frequently required to remain at work for extraordinary periods between fire cleanings, and during such intervals with the forcing of fires to the maximum, doing short service and pushing trains up to grade, together with drifting down grade, and long time between trips, there is considerable opportunity for variation in the temperature in the firebox and flues, which would tend to cause leakage and failure. Under such conditions, however, No. 2400 has been able to meet the requirements, and at the same time make use of an ordinary grade of run-of-mine bituminous coal, and maintain ample boiler pressure at all times to handle the work.

It may be added that the greatest curvature on the line over which No. 2400 operates is about 9 deg., while on the heaviest grade there is a reverse curvature of about 7 deg.

MOTOR-DRIVEN CRANK SHAPER.

The accompanying photograph illustrates an interesting motor application to a Cincinnati 24-in. back geared crank shaper. The casting to which the motor is attached is hinged at its lower end, while the upper end may be adjusted for the purpose of tightening the belt by means of the cap and set screw. The motor shown is a Jantz & Leist 110-volt constant speed 5-h.p. This shaper is on exhibition at the Liege Exposition in Belgium and is equipped with a motor of foreign



CINCINNATI MOTOR-DRIVEN CRANK SHAPER.

make, the one shown in the photograph being put on for test purposes before the machine was shipped. This accounts for the fact that it does not exactly fit the pads on the tilting leaf. The back gears are controlled by the rod shown near the base of the machine just below the cone pulley. The gear protected by the casing just above this rod is keyed on the driving shaft or shaft which carries the cone pulley on the standard belt

driven machine. This is driven by a small pinion on the shaft above, which in this case carries the cone pulley. The ram may be adjusted by hand by means of the small wooden hand wheel on the end of the pulley shaft; the curved handle at the side of the machine operates a brake on the inside of the pulley.

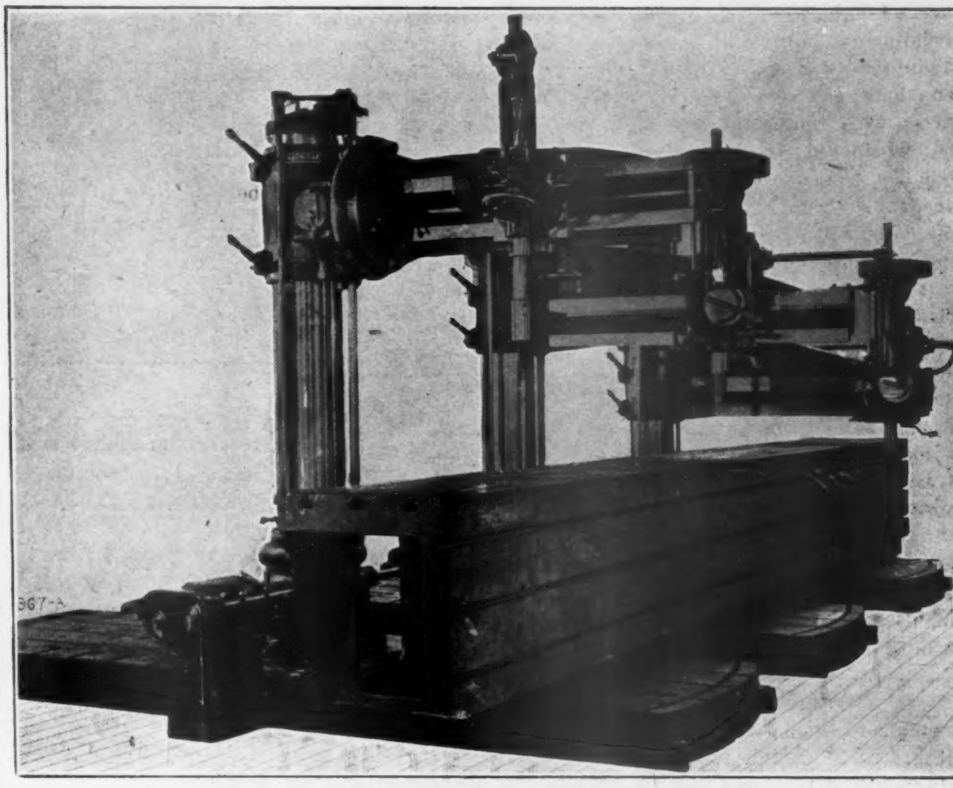
The machine is equipped with very powerful gearing and the design throughout is such that the work can be very accurately turned out under the most severe conditions of cutting. The column, which is very wide and deep, is ribbed and braced internally; horns project at the front and rear, thus affording an unusually long bearing for the ram. The length of the stroke may be changed while the machine is at rest or in motion. The cross transverse screw for the rail is provided with a graduated collar reading to .001 of an inch and with a variable automatic feed which may be changed from nothing to full speed while the machine is in motion. The head swivels to any angle and is graduated. The cross feed connecting rod is automatically adjustable to any height of the rail and does not depend upon frictional contact. The rail is raised and lowered by means of a telescopic screw which works on ball bearings. The outer support for the table is rendered very efficient by making the base stiff enough to rigidly withstand the thrusts which come upon it and care is taken to have the surface upon which the support slides made truly parallel with the travel of the table. The vise is of the double screw form and has a graduated swiveling base. An opening through the column under the ram provides for the keyseating of shafting and similar work up to 4 ins. in diameter. This machine weighs about 4,000 lbs., and is made by the Cincinnati Shaper Company.

LOCOMOTIVE FRAME DRILLING MACHINE.

The Louisville & Nashville Railroad has just installed in the new shops at Louisville a combination radial and locomotive frame drilling machine which consists of three 6-ft. radial drills, two plain and one full universal, each with a double base and one long T slotted table extending across them. It is designed with a view to working the high speed drills, taps and reamers to the limit of their efficiency. Each drill is a complete unit in itself and may be used either for work on locomotive frames clamped to the long table or the arm may be swung around to do the regular radial work on the opposite end of the base or on a box table which is furnished but not shown. Sufficient room is allowed between the columns so that each arm may be swung in a complete circle.

The three drills are driven by one direct current electric motor through the medium of a four-speed box on the base of each, which may be operated by the two levers while the machine is running. The speed boxes are connected to the drills by means of spur gearing, thus obviating all end thrust. The three drills are connected by couplings, the shaft which connects to the motor passing through the lower part of the stump or inner column in which it has its bearing. The inner columns extend to the top of the columns, and rigidly support them. The back gears are on the heads and deliver the power direct to the spindle and are easily controlled by levers conveniently placed for the operator. When the operator is tapping with the back gears in he can thus instantly change to a higher speed for backing out without changing his position or stopping the machine. The spindle may be started, stopped or reversed by a lever on the head, convenient to the operator, which obviates the necessity of stopping any of the running parts except the spindle. The tapping mechanism is controlled by the same lever and is carried on the back of the head between the back gears and the speed box, thus giving to the powerful friction the benefit of a high back gear ratio which makes possible unusually heavy tapping operations.

The plain radials have eight positive feeds ranging in geometrical progression from .007 to .063 ins., each instantly and easily obtainable through two dials on the head which clearly show the various feeds. The power feed is delivered from the worm wheel to the spindles through a powerful friction controlled by a handle used for quick advance or return. The full universal radial has four positive feeds ranging from .007 to .045 ins., any one of which may easily be obtained by moving a knob to a given notch. Depth gauges and automatic stops are provided and the spindle is graduated. The spindle is also provided with a safety stop which prevents it from feeding beyond the limit. All the gears are protected by casings. This machine is made by the American Tool Works, Cincinnati, O.



AMERICAN LOCOMOTIVE FRAME DRILLING MACHINE.

HIGH-SPEED TWIST DRILLS.

While high speed drills have been in use long enough to demonstrate their great superiority over the carbon drills and are fast replacing them it is difficult to obtain definite information as to the average working speeds and feeds at which it is desirable to use them on different classes of materials. Because of the large number of varieties of iron and steel it is, of course, impossible to fix feeds and speeds suitable for all, and it is necessary for each user to determine this for himself, at least to a large extent. It is possible, however, to assist him by laying down a schedule of feeds and speeds which have been successfully used in general work and will at least establish a starting point in his investigations. In many cases it will be found impossible to work anywhere near the safe limit of these drills because the larger number of drill presses now in service are not powerful enough or have not a sufficient range of speeds, and it is therefore necessary

to adopt such speeds and feeds as are suitable to the machines. The revolution in the design of drilling machines caused by the use of high speed drills was commented upon on page 182 of our May issue.

The general statement has been made that these drills will run at about twice the speed and feed of the ordinary carbon steel drills, but an investigation seems to show that, while this is approximately true concerning the feeds, the speeds may be increased to considerably more than double those used with carbon steel. The following tables show the working speeds and feeds as recommended by the makers of two well-known high speed steels for use on mild steel, wrought iron and soft cast iron:

WORKING SPEEDS AND FEEDS FOR HIGH SPEED TWIST DRILLS.

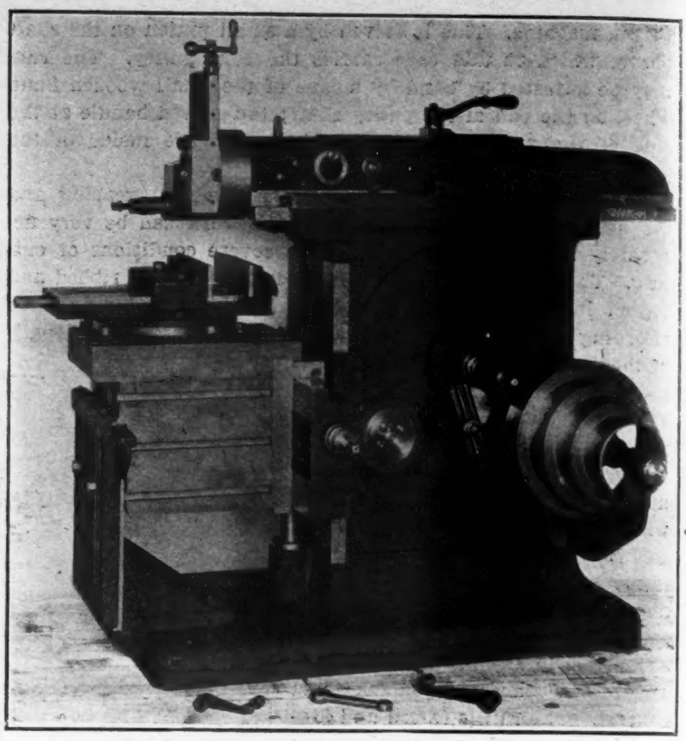
Diameter of Drill, ins.	A		B	
	Speed, R. P. M.	Approx. Feed Per Rev.	Speed, R. P. M.	Approx. Feed Per Rev.
1/4	980	.008	1,050	.008
5-16	785	.008	850	.008
3/8	625	.01	700	.011
7-16	600	.01	600	.011
1/2	585	.01	525	.016
5/8	470	.013	425	.016
3/4	365	.013	350	.016
7/8	300	.013	300	.016
1	260	.015	260	.020
1 1/8	220	.015	230	.020
1 1/4	200	.015	215	.020
1 3/8	165	.015	200	.020
1 1/2	150	.015	180	.020
1 3/4	110	.015	150	.020
2	105	.017	130	.020
2 1/4	100	.017	120	.020
2 1/2	96	.017	105	.020
2 3/4	92	.017	100	.020
3	80	.017	90	.020
3 1/4	75	.017	...	...
3 1/2	68	.017	...	...
3 3/4	64	.017	...	...
4	60	.017	...	...

These are the average working speeds and are considerably lower than speeds and feeds which are being successfully used in very many cases. The makers' names are withheld, as it is quite possible that one of them may have been more conservative in his estimates, and it might lead to drawing an unfair inference concerning the comparative value of the two steels. In both cases successful tests were described of high speed drilling at much higher rates than those recommended for general use, in fact, the maker of the steel A states that they are able to drill through cast iron at the rate of 24 ins. per minute and through mild steel at the rate of 12½ ins. per minute. The maker of steel B advises that in nine cases out of ten it will be possible to run the drills at 25 per cent. higher speeds on cast iron than shown in the table, and that on brass the speeds may be doubled, and in all cases the drills should be run dry. With steel A a lubricant should be used for mild steel, but not for cast iron.

20-INCH CRANK SHAPER.

The accompanying photograph illustrates a newly designed 20-in. Stockbridge crank shaper which has several noteworthy features. The automatic feeds to both the head and table are adjustable while the machine is in motion. The outer table support supports it for its entire width; the table is raised sufficiently above the saddle to allow the T bolts to be put in from the back as well as from the front; the table hooks over the saddle, thus making it more rigid than when the bolts alone are used. The driving gear is 20 in. in diameter and has a 3½-in. face, and this, together with back gears and the 4-step cone driven by a 3-in. belt, makes a very powerful machine. It is equipped with the Stockbridge 2-piece crank motion, which furnishes a powerful and even cutting speed for the entire length of the cutting stroke and gives a very quick return. The crank and gear are so constructed that the shaper has the same rigidity on the long stroke as on a short one, the cut on the 20-in. stroke being as free from chatter as on the 5-in. stroke.

The column is extended at both the front and back at the top, thus giving a long bearing for the ram. The swivel for the head is accurately graduated and may be set at any angle and is clamped in position by two bolts which hold it rigidly. The slide has a travel of 9 in. and is fitted with an automatic



STOCKBRIDGE 20-IN. CRANK SHAPER.

feed. The table has a working surface at the top of 14 by 20 ins. The stroke may readily be changed from the front of the machine. The table has a cross feed of 26 ins. and is automatic in either direction. It has a vertical movement of 13 ins. by means of the bevel gears and a telescopic screw, which is provided with ball bearings. The rocker arm and column are so constructed that a shaft as large as 4 ins. in diameter may be passed under the ram for keyseating. The vise has a swivel base which is graduated and may be set at any angle. The jaws are 3 by 12 ins. and open 12 ins. The finished machine and counter shaft weigh about 3,200 lbs. It is made by the Stockbridge Machine Company, Worcester, Mass.

BALANCING BALANCED COMPOUND LOCOMOTIVES.

METHOD OF COUNTERBALANCING REVOLVING PARTS ON A CRANK-AXLE.

In the balanced compound locomotive only the revolving weights are considered as the reciprocating parts move to and fro, balancing each other, and have no effect on the rail. The method employed by the Baldwin Locomotive Works in determining the position and weight of each counterbalance is as follows:

The revolving weights are concentrated at two points on each side of the engine; that is, at the centers of gravities of the outside pins and of the inside crank pins. These weights are made up (Fig. 1) as follows:

(a) Weights concentrated at each inside crank pin, composed of two crank cheeks, inside crank pin, back end of main rod. These weights will be known as W_a.

(b) Weights concentrated at each outside pin, composed of wrist pin, wrist pin hub, front end of side rod and, if so coupled, the back end of the main road. These weights will be known as W_b.

The throw of the weights W_a is balanced by two weights, one in each wheel, throwing in the opposite direction to the crank weights, and of such magnitude that the three parallel forces thus produced shall balance each other, any one being, therefore, equal and directly opposed to the resultant of the other two. The throw of the weights W_b is balanced by a weight in the wheel on the same side throwing in the opposite direction and by one in the opposite wheel throwing in the same direction, the respective weights being of such magni-

tude that the system of parallel forces so produced shall balance each other.

From the above it will be seen that in the left wheel the counterweights which balance the revolving weights of the right side are at 90 deg. to those which balance the revolving weights of the left side of the engine. In each wheel there will, therefore, be two counterweights, one opposite the inside crank and one at right angles. These two weights can be combined by either graphical or analytical methods.

In Fig. 2 let W_a = weights of inside crank pin.

W_b = weights at outside crank pin.

a_1 and a_2 = distance of centers of gravities of counterbalances from W_a.

b_1 and b_2 = distance of centers of gravities of counterbalances from W_b.

The weights C required in left wheel (Fig. 3) to balance W_a

$$C_1 \times (a_1 + a_2) = W_a\ a_2$$

$$C_1 = \frac{W_a\ a_2}{a_1 + a_2}$$

the weight C_2 in the right wheel being

$$C_2 = \frac{W_a\ a_1}{a_1 + a_2}$$

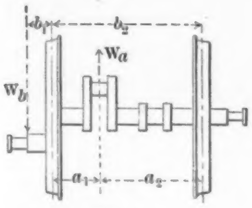


FIG. 1

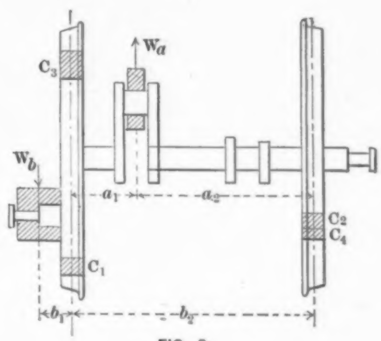


FIG. 2

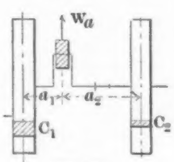


FIG. 3

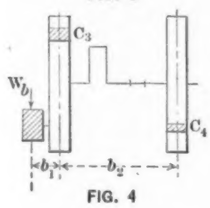


FIG. 4

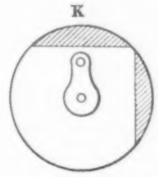


FIG. 5

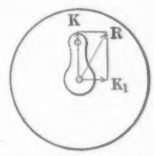


FIG. 6

FIG. 7

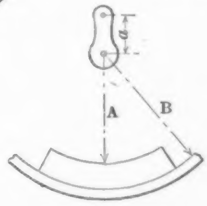


FIG. 8

These two weights throw in the opposite direction to W_a. The weight C_3 required in the left wheel (Fig. 4) to balance outside weights W_b.

$$C_3\ b_2 = W_b\ (b_1 + b_2)$$

$$C_3 = \frac{W_b\ (b_1 + b_2)}{b_2}$$

This weight is opposite to the pin. The required weight C_4 in the right wheel being

$$C_4 \times b_2 = W_b\ b_1$$

$$C_4 = \frac{W_b\ b_1}{b_2}$$

This weight throws in the same direction as the weights W_b.

Since W_a and W_b are 180 deg. apart, the counterweights to balance them in the left wheel will likewise be opposed to each other, the actual weight to use will therefore be

$$K = C_3 - C_1.$$

The weights in the left wheel which balance the revolving weights on the right side both throw in the same direction and at 90 deg. from the weights just determined, therefore, a second weight (Fig. 5)

$$K_1 = C_2 + C_4$$

must be placed 90 deg. from the above.

These weights can be combined either analytically or graphically, and both their magnitude and direction determined by the usual method of scaling two lines at right angles to each other, their length being proportionate to the counterweights completing the parallelogram, the diagonal of which will give both the size of the resultant weight and the angle at which it should be placed.

It can also be determined analytically (Fig. 6):

$$R = \sqrt{K^2\ K_1^2}$$

and $\frac{K}{K_1}$ = tangent of the angle.

To this point the weights can be considered as acting at a radius equal to the crank arm. The weight at the rim of the wheel can be calculated irrespective of the diameter of the wheel (Fig. 7).

$$\text{Chord A B} = \sqrt[3]{\frac{12\ R\ a}{t\ q}}$$

R = Known weight at crank pin radius a.

t = Thickness of counterbalance.

q = Weight of cu. in. of metal.

In applying the formula the thickness should be assumed. The sector balance (Fig. 8) can be calculated as follows:

$$A = \sqrt[3]{B^3 - \frac{3\ R\ a}{2\ t\ q\ \sin \frac{180\ M}{n}}}$$

B = Outside radius.

A = Inside radius.

n = Number of spokes.

M = Spaces to be filled by balance.

GRINDING IN LOCOMOTIVE REPAIR SHOPS.

In connection with an article on grinding processes for locomotive repair work in the Collinwood shops of the L. S. & M. S. Ry., on page 145 of our April, 1903, journal, the Norton 18 by 96-in. plain grinding machine was described, and the accuracy and rapidity with which crank pins, piston rods and valve stems were finished was commented upon. The accompanying photograph shows several samples of work done on one of these machines which were exhibited at the Railway Appliance Exhibition in connection with the International Railway Congress. The piston and rod in the center were in service on the Lake Shore for some time, and the rod was repaired by grinding without re-turning. The ring shown near the top is made in two halves, with solid joints, and was very carefully fitted to the rod. The rod is ground so straight and true that with the ring fitted to move freely no variation in friction can be detected. This is a very severe test, for a variation of .0001 in. may be easily detected with a ring fitted as carefully as this one was.

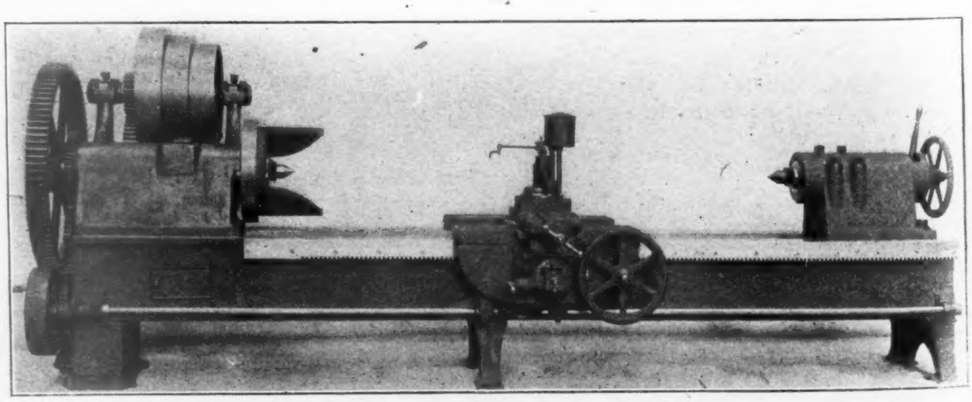
We are told that an operator at the Collinwood shops ground a pair of these rods with the pistons on in 30 minutes, taking them from the floor, finishing them and replacing them on the floor in that time. On some parts of the rods, owing to the sprung condition, it was necessary to reduce the diameter as much as 1-32 in. The average time, however, required for grinding such rods with an ordinary operator is about 30 minutes each. A new rod if properly or cheaply turned requires about the same time for grinding as an old one does. If turned with the same finish as required for filing, a good operator does not require more than five minutes to finish the rod by grinding. It is, however, more profitable to give it a rougher finish and remove a larger amount of metal by grinding.

EXAMPLES OF GRINDING IN LOCOMOTIVE REPAIR SHOPS.

The time required for grinding crank pins, such as shown in the photograph, is about 15 minutes each if they are cheaply turned with a coarse finish, as shown on the unfinished portion. The new piston rod resting on top of the crank pins and with the ends left blank was ground accurately to .00025-in. limits for roundness and straightness. The wheels standing in the front of the table are the ones used for grinding this work; the one on the right has a 4-in. face, and is used for grinding piston rods, while the one at the left has a 2-in. face and is used for grinding crank pins and valve stems. The machine upon which this work is done is arranged so that the valve stem yoke and the piston swing in the same gap. It was designed specially for locomotive work, and is one of several different types of grinding machines made by the Norton Grinding Company, of Worcester, Mass.

HEAVY TURNING LATHE.

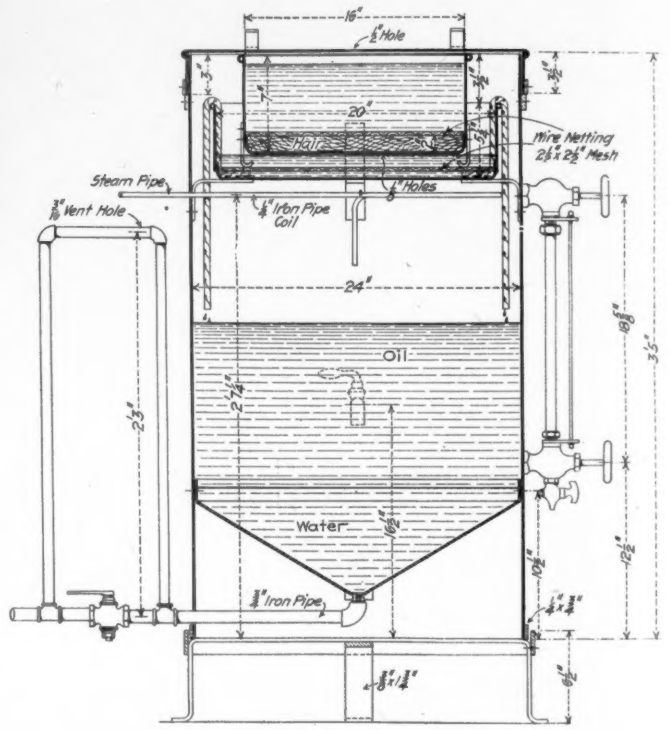
The heavy Sellers' lathe shown in the photograph is intended for turning locomotive axles and similar work, and swings 25 ins. diameter over the bed and 13½ ins. over the carriage. It is especially adapted for the use of the high-speed steels, and is designed to overcome a force of 20,000 lbs. at the tool when turning a 10-in shaft, 25,000 on an 8-in diameter and 33,000 on a 6-in. diameter. The tool carriage is very heavy, the spindles in both the head and tailstocks are large in diameter and have steel centers. The bed is flat on top, with vertical guiding surfaces. The tailstock spindle is clamped in two places, and centered by a patent double cone grip. The tailstock is held with six bolts, and has a patent under V guide. Positive geared feeds are provided, and the feed rack is steel with cut teeth. The face plate is provided with a Clement's double driver. The lubricant for the cutting tool is forced through a circulating system of pipes by means of a power pump. This lathe is made by William Sellers & Co., Inc., Philadelphia, Pa.



SELLERS HEAVY LATHE FOR LOCOMOTIVE AXLES.

OIL FILTER.

The accompanying illustration shows an oil filter for the waste oil from stationary engines which is simple in construction and operation, and has given very satisfactory results at the Depew shops of the New York Central. The oil is emptied into the small upper tank, and filters down through the wire netting and hair felt into a second tank, and is siphoned by the candle wicking from this into the large tank. The ¼-in. steam pipe coil is used to warm the oil to about 125 deg., so that it will flow freely. As the steam from this condenses the water settles to the bottom of the tank and is drained off by means of the valve in the ¾-in. pipe. The inverted U in the ¾-in. pipe allows the water to drain off if the level in the tank becomes too high. The oil is removed from the large tank by the valve at the side. We are indebted to Mr. J. F. Deems, general superintendent of motive power of the New York Central Lines, for this information.



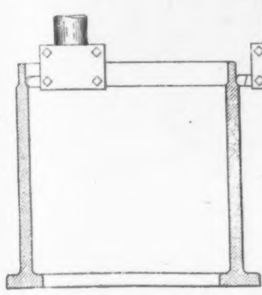
OIL FILTER—DEPEW SHOPS.

Thirty-six and nine-tenths per cent. of the world's production of coal, or 319.1 million tons, were produced in the United States in 1903.

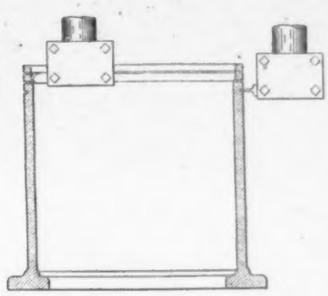
PRODUCTION IMPROVEMENTS.

PACKING RINGS FOR PISTONS.—One hundred and twenty-two packing rings in 10 hours is the record of a 42-in. Bullard standard boring mill, as shown at the Railway Appliance Exposition held last month at Washington. At the Bullard exhibit the following facts are shown from a record made at the West Albany shops of the New York Central & Hudson River Railroad.

The material is, of course, cast iron, and the rings are turned up from cylinders as indicated in the two sketches showing the first and third operations, the finished packing rings being ⅝ x ⅝ ins. in section. The second operation is to take a ½ in. finishing feed on the outside. The record of 10 hours' work is given in the following table:



FIRST OPERATION.



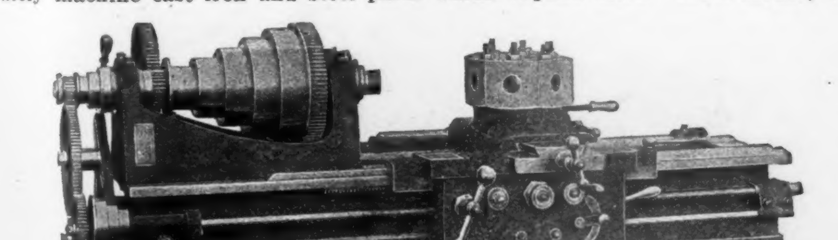
THIRD OPERATION.

Castings.	Diameter.	Rings.	Diameter.	Hours.	Minutes.
1	19½ ins.	13	18½ ins.	1	5
1	19½ ins.	14	18½ ins.	1	5
1	19½ ins.	14	18½ ins.	1	5
1	20 ins.	13	19 ins.	1	5
1	20 ins.	13	19 ins.	1	5
1	20 ins.	13	19 ins.	1	5
1	21 ins.	14	20 ins.	1	10
1	21 ins.	14	20 ins.	1	10
1	21 ins.	14	20 ins.	1	10
9 Castings.		122 Rings.		9 Hrs.	60 Min.

This record attracted a great deal of attention, as well it may. The machine is heavy, convenient to handle, and such work is rendered possible in any railroad shop. Further information may be had from the Bullard Machine Tool Company, Bridgeport, Conn.

LATHE WITH TURRET ON THE CARRIAGE.

The photograph shows an 18-in. standard Springfield lathe equipped with a friction geared head and a turret on the carriage in place of the regular compound rest. This lathe has been made to meet the demand from railroad shops and automobile builders for a machine which could rapidly and accurately machine cast iron and steel parts which require more than one operation, and serve the purpose of a heavy turret lathe.



SPRINGFIELD LATHE WITH TURRET ON CARRIAGE.

While the friction geared head adds to the cost of the machine, it is very desirable on a standard engine lathe, and is indispensable on screw machines and turret lathes. The frictions are carefully constructed, with convenient means of adjusting for wear, and will last as long as the machine itself.

The carriage, which is very heavy and is gibbed to the outside of the bed at both front and back, is fitted with a turret slide 10 ins. in width and 16 ins. in length upon which the turret revolves. The turret is hexagonal in form, 10½ ins. wide across flats, and the holes are 2 ins. in diameter. Provision is also made for bolting special cutters to the faces of the turret. The index pin and clamping lever are at the right side of the turret in a convenient position for the operator, but entirely out of the way. The lathe is provided with a power cross feed, a longitudinal feed and a screw cutting apparatus, and, if desired, may be equipped with a taper attachment. It weighs about 2,400 lbs., and is made by the Springfield Machine Tool Company, of Springfield, Ohio.

VICTOR AUTOMATIC LOCOMOTIVE STOKER.

The automatic stoker as applied to locomotives has demonstrated its capability for feeding and satisfactorily spreading more coal than can possibly be handled by any fireman. It has handled as much as 18,000 lbs. per hour, spread over a surface of 8 ft wide by 9 ft. long, thus demonstrating its capacity to be more than equal to the greatest demands of locomotive service. The Victor stoker, formerly known as the Day-Kincaid, was exhibited at Washington during the convention of the International Railway Congress, being shown in operation, using chestnut anthracite because of its cleanliness, although it is generally used with bituminous coal. Because of the fact that this stoker will handle slack coal as efficiently as run-of-mine, it affords an opportunity for a saving in operating cost, entirely independent of the economy of mechanical stoking. Extensive road tests have indicated the possibility of saving from 6 to 7 per cent. of coal, due to mechanical stoking, but if it saves no fuel, the automatic stoker may be expected to pay its way into locomotive practice by permitting the use of cheaper fuel. Information obtained from results of practice indicate that runs of 500 miles are made without cleaning fires, an impossibility under similar conditions with hand firing.

The Victor stoker was first applied on the Cincinnati, Indianapolis & Chicago division of the "Big 4" Railroad in January, 1905; by March 5 seven engines were equipped and in operation, five of them being of the Atlantic type and all in fast passenger service. Six stokers were operated through the February blizzards with great satisfaction. They were in the hands of men who had no previous knowledge or experience with the device. The only difficulties resulted from lack of lubrication or breakage by improper methods, such as the breaking of coal in the hopper with a pick. In the daily service between Cincinnati and Indianapolis the engines referred to run 120 miles and return without cleaning fires, this being a result of the ability to carry a clean thin fire and because the fireman had time to properly take care of the grates. It has been demonstrated that ordinary firemen use the stoker very satisfactorily after an experience of only a few days. The operation of the stoker is improved as the men become more familiar with it.

Further information may be obtained from Mr. H. W. Fullerton, general manager of the Victor Stoker Company, Cincinnati, O., manufacturers of the stoker.

FIFTY-TON HOPPER COKE CAR.

50-TON STEEL COKE CAR.

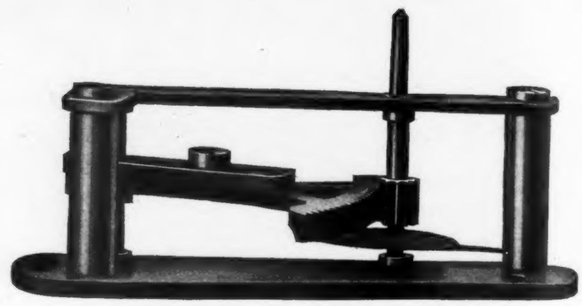
The side dump coke car shown in the illustration was designed and built by the Pressed Steel Car Company to meet the demand of the coke carrying roads for a large capacity car of a minimum light weight provided with a drop door arrangement to insure the rapid discharge of the lading. A large number of these cars are now in operation and are built to the following dimensions:

Length over end sills	41 ft. 9 ins.
Length inside	40 ft. 5 ins.
Center to center of trucks	32 ft. 1 in.
Width of car inside	9 ft. 7 ins.
Height from top of rail to top of sides	12 ft. 0 in.

This gives a cubical capacity sufficient for 100,000 lbs. of coke, and with heavy arch bar trucks, having 5½ x 10-in. journals and 700-lb. wheels, the total light weight is only a trifle over 47,000 lbs.

The side and floor slopes present no obstruction to the free discharge of the lading; the doors are of ample proportions and are actuated by a simple and effective mechanism which is operated from one end, the doors on each side of one end being controlled by the operating lever which has a pawl to engage with the ratchet wheel on the outer end of the horizontal shaft shown in the center just above the draft sills, on the other end of which shaft is a double chain sheave to which the ends of the driving chain are anchored. The other ends of the chain are secured to a double sheave on one of the door shafts which are shown parallel with each other below the center sills, and immediately behind this double sheave is a pair of toothed gears transmitting the motion simultaneously to both shafts. Keyed to both door shafts are bent lever arms to which the door links are connected. This arrangement gives a self-lock and eliminates any twisting movement due to the weight of the lading against the doors. The doors are easily operated and several tests have been made with the cars after they have been hauled long distances with full loads of coke and under severe weather conditions and in each instance the entire load has been discharged in less than thirty seconds without any manual labor other than that necessary for operating the doors.

Care of Machine Tools.—A small amount of care and attention regularly given to the average machine tool will maintain it in a high state of efficiency and will add considerably to its length of life.



SHOWING MECHANISM OF STEAM GAUGE.

INDICATOR WITH IMPROVED DETENT MOTION.

NEW STEAM ENGINE INDICATOR.

A new improved detent motion for the American-Thompson indicator has been brought out by the American Steam Gauge & Valve Manufacturing Company, of Boston. This attachment renders the well-known American-Thompson indicator specially applicable to high-speed stationary and marine engines; also to locomotives and gas engines. With this attachment it is possible to connect the indicator to high-speed reducing motion and stop the drum of the indicator without unhooking the cord, and, of course, without stopping the engine. The vexation attending the stopping and starting of the drum carriage of the ordinary indicator for changing cards is entirely avoided by this new attachment. This will be specially appreciated by those who are called upon to get as many cards as possible in a short time in a locomotive test, where the difficulties of indicating at best are very great. The locomotive indicator has a 1½-in. paper drum, and is specially adapted for high speed and rapid work, which is necessary to meet the conditions of rapidly changing load.

The detent motion is contained within the paper drum, and is operated by means of a lever below the drum carriage. To stop the drum this lever is moved in the direction travelled by the drum. When released it is returned by the auxiliary spring to a position ⅛ in. beyond the end of the stroke, rendering it impossible for the drum to engage until desired. The drum carriage, having the full tension of the main drum spring, continues to rotate, which prevents whipping and sagging of the cord. This permits the indicator to be used with the detent motion in connection with a reducing wheel directly connected with the indicator. The drum is supported on the spindle by means of a collar held stationary by a pin engaging the slot in the spindle, on which rotates an outer sleeve, which acts as a bearing and guide for the drum. To the stationary collar is fastened the inner end of the auxiliary spring case, which is held stationary in the paper drum. The tension of this spring is such as to cause the drum to return to its position before the return stroke of the drum carriage. When in action the drum is controlled by a pin engaging a hole in the grooved wing at the bottom of the drum. By turning the lever, this pin is lowered on the return stroke of the drum carriage, releasing the drum, which is returned beyond the end of the stroke by the auxiliary spring. The lever is then returned to its original position, allowing the pin to elevate again. When the card is changed and ready to take another diagram, the drum is turned forward by means of the milled rim on top. This causes the pin to engage the hole, being guided by an incline, causing the drum to rotate in the usual manner, the motion being smooth and without shock, there being no chance to break the cord as with the old style pawl and ratchet detent motion.

In connection with this make of indicator the well-known original Thompson parallel motion is used; the ratio of the lever being three to one, makes a very stiff and rigid motion. The piston and other working parts of the instruments are made as light as practicable. The piston head and steam cylinder are made of special composition, which gives an equal expansion under the varying thickness of metal; this is particularly desirable in reducing friction at this point.

IMPROVED LOCOMOTIVE STEAM GAUGE.

The American Steam Gauge & Valve Manufacturing Company has also introduced a new gauge, which is specially worthy of attention by those who are responsible for steam gauges on locomotives. This construction employs a specially heavy tube for the purpose of preventing vibration and rendering the gauge stiff and rigid. Hard German silver plates are used for connections, the screws and pins being of phosphor bronze, to prevent corrosion and undue wear in the working parts. The movement of the gauge is fitted with a wide-faced segment for the purpose of increasing the life, by reducing wear. The pinion and pinion shaft are of one piece of hard phosphor bronze, the segment shaft also being made of

IMPROVED LOCOMOTIVE GAUGE.

the same metal. The top and bottom plates of the movement have deep German silver bushings, giving unusually long bearings for the pinion and segment shafts. By the use of the hard and rigid connections the lost motion in this gauge is very slight, as may be ascertained by moving the parts with the finger. This is an important factor in locomotive service. There is no iron or steel in this gauge. The case is very heavy, the ring screwing down to the shoulder to make it dust proof. The purpose of the improvements is to secure accuracy because of reduction of wear, durability for the same reason, and simplicity contributes to the desired result by reducing to a minimum the number of parts and connections, making the whole combination as short and direct as possible.

PERSONALS.

Mr. J. F. Mann has been appointed general foreman of the Pere Marquette Railway at Saginaw, Mich.

Mr. J. K. Kelker has been appointed master mechanic of the Cincinnati, Hamilton & Dayton, at Lima, Ohio.

Mr. F. L. Fox has been appointed general foreman of the Pere Marquette Railway at Ionia, Mich.

Mr. D. McKinley has been appointed general foreman of the car department of the Pere Marquette Railway at Muskegon, Mich.

Mr. J. M. Gardner has been appointed assistant master mechanic of the Pennsylvania Railroad at Trenton, N. J.

Mr. E. C. Rodie has been appointed general foreman of the machine shops of the Illinois Central Railroad at New Orleans, La.

Mr. F. W. Cooper has been appointed master mechanic of the Lehigh Valley at East Buffalo, N. Y., succeeding Mr. J. H. Fildes, resigned.

Mr. J. P. Dorsey has been appointed master mechanic of the Ohio River division of the Baltimore & Ohio, with headquarters at Parkersburg, W. Va.

Mr. G. W. Tompkins has been appointed master mechanic of the Wabash, Chester & Western Railway, with office at Chester, Ill., to succeed Mr. E. Danks, resigned.

Mr. J. D. Macbeth, roundhouse foreman of the New York, Chicago & St. Louis at Buffalo, has been appointed master mechanic at Conneaut, O., to succeed Mr. E. A. Miller, promoted.

Mr. Alex. Kearney, superintendent of motive power of the Baltimore & Ohio at Pittsburgh, has resigned to become assistant superintendent of motive power of the Norfolk & Western, with headquarters at Norfolk, Va.

Mr. H. C. Van Buskirk has been appointed superintendent of motive power of the Colorado & Southern Railway to succeed Mr. A. L. Studer, resigned. Mr. Van Buskirk was formerly general master mechanic of the Fort Worth & Denver City Railway at Childress, Texas.

Mr. G. W. Rhodes, general superintendent of the Burlington & Missouri River, has resigned, after 25 years of service with the Burlington system, closing a most useful and honorable railroad career, in which he has placed his name permanently among the highest and best American railroad officials.

Mr. E. A. Miller has been promoted from the position of master mechanic of the New York, Chicago & St. Louis Railway to that of superintendent of motive power, with headquarters at Cleveland, O., to succeed Mr. W. L. Gilmore, resigned. Mr. Miller has been master mechanic at Conneaut, O., for 23 years.

Mr. F. H. Clark, who has been superintendent of motive power of the Chicago, Burlington & Quincy Railway since March, 1902, has been appointed general superintendent of motive power of the Burlington lines, his headquarters remaining in Chicago. Mr. F. A. Torrey has been appointed to succeed Mr. Clark as superintendent of motive power.

NEW CATALOGS.

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS PAPER.

DYNAMOS.—Bulletin No. 2 from the Burke Electric Company, Erie, Pa., describing their type "AB" and "AM" dynamos for direct current.

FISH AND GAME LAWS OF MAINE.—A folder received from Mr. C. C. Brown, general passenger and ticket agent of the Bangor & Aroostook Railroad, gives in compact form the fish and game laws for the season of 1905-1906.

ELECTRIC FANS, A FEW WORDS ABOUT.—Bulletin No. 54 from the Crocker-Wheeler Company, Ampere, N. J., describes the Davidson propeller fans driven by direct connected motors, which they are prepared to furnish in sizes from 18 to 60 ins.

RAILWAY GENERATORS.—Bulletin No. 52 from the Crocker-Wheeler Company, Ampere, N. J., contains a very complete description of their direct current generators for electric railways. Several typical applications of these generators are illustrated.

BUDA PRODUCTS.—The Buda Foundry & Manufacturing Company are distributing an attractive 6 by 9 in., 225 page 1905 catalog. A few of the lines which this company manufactures are hand, push and inspection cars, railroad velocipedes, track drills, track and wrecking jacks, track construction tools, roadway signs, a complete line of switch stands and signals, crossing gates, wrecking frogs, brake shoes, anti-friction metal, station stoves and the many products of its special work department, the Paige Iron Works. The catalog concludes with 13 pages of useful engineering information.

AIR COMPRESSORS.—The Chicago Pneumatic Tool Company, Chicago, will be pleased to send those who are interested a copy of their new catalog describing the new pattern type G Franklin compressors, which are lighter in construction than the standard Franklin machines.

STAYBOLT IRON.—The Old Dominion Iron & Nail Works Company, Richmond, Va., have issued a pamphlet which presents some interesting facts concerning the advantages of their special vibrating staybolt iron.

TRACK, CONSTRUCTION AND MAINTENANCE.—We have just received from the Buda Foundry & Manufacturing Company, Chicago, Ill., copies of both the English and French editions of their interesting catalog describing the large variety of track and maintenance of way specialties manufactured by them.

"MORE LATHE WORK AND FEWER LATHES."—Under this title the Lodge & Shipley Machine Tool Company, Cincinnati, O., have issued a nicely gotten up and well illustrated catalog which describes in detail the various parts of their Patent Head lathe, which is a quick change gear lathe adapted for high-speed work.

DIRECT CURRENT GENERATORS.—Bulletin No. 46 from the Northern Electrical Manufacturing Company, Madison, Wis., describes and profusely illustrates the details of their direct current generators, which are adapted for furnishing power and light for railroad shops. Several typical applications of these generators are also illustrated.

WESTINGHOUSE CATENARY LINE CONSTRUCTION.—Circular No. 1,110, issued by the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., gives a very complete description of their catenary line construction, which is intended for high-tension trolley roads and was especially designed for use in conjunction with their single phase alternating current equipment.

ONE DAY'S WORK.—The Bullard Machine Tool Company, Bridgeport, Conn., have issued bulletin F 537, which illustrates their 42 in. standard boring and turning mill with two swivel heads, and shows how 122 piston packing rings were made in ten hours on one of their machines in the West Albany shops of the New York Central Railroad.

THE WESTINGHOUSE COMPANIES IN THE RAILWAY AND INDUSTRIAL FIELDS.—The publication department of the Westinghouse companies is to be congratulated upon bringing out this handsome and well arranged publication, which briefly but interestingly traces the development of the various Westinghouse companies from their inception to the present time and illustrates a few of their many products.

THE EVOLUTION OF CAR COUPLINGS.—The McConway & Torley Company, Pittsburg, Pa., distributed at the International Railway Congress in Washington an interesting and handsome publication, printed in English and French in parallel columns, which traces the development of car couplings from the old link and pin style to the present time. This company co-operated with Janney in developing his coupler, and was, therefore, the original promoter and manufacturer of the M. C. B. type of coupler.

ELECTRICAL APPARATUS.—The American Electric & Controller Company, 136 Liberty street, New York City, has ready for distribution the following bulletins: No. 1, description of the rheocrat; No. 2, applications of the rheocrat; No. 3, electrically operated switches; No. 4, automatic starters for induction motors; Nos. 5 and 6, applications of automatic starters; No. 7, solenoids for direct and alternating current service; No. 8, applications of solenoids. A suitable binder will be furnished in which to preserve these bulletins.

NOTES.

AMERICAN ELECTRIC & CONTROLLER COMPANY.—This company has removed its office from 12 Dey street to the Electrical Exchange Building, 136 Liberty street, New York City.

AJAX METAL COMPANY.—This company is constructing a new fireproof pattern loft at 52 Richmond street, Philadelphia. The construction is to be of steel. Mitchell Bros. of Philadelphia have the contract for erection.

The American Water Softener Company.—This company reports the receipt of an order from the Hocking Valley Railway which includes a water softening plant to be installed at their Columbus shops, with a capacity of 25,000 gals. an hour, or 600,000 gals. a day.

Magnolia Metal Company.—Mr. H. W. Toothe has resumed his position in the sales department of this company, with headquarters at 113 Bank street, New York City.

Steam Turbine Unit for a Railroad.—The Canadian Westinghouse Company, Limited, has sold a 500-k.w. enclosed type turbo-generator unit to the Canadian Pacific Railway, to be installed at Fort William, for supplying power to the various grain elevators at that point. The unit is to operate 3 phase. 600 volt, 7,200 alterations, 3,600 r.p.m.

Buda Foundry & Manufacturing Company.—Mr. James H. Bannerman, formerly mechanical superintendent of the Tennessee Central, has been added to the force of travelling representatives and will represent the metal department, demonstrating to the mechanical departments of the railroads the advantages of some of the new compositions which they have recently placed on the market.

The Garford Company.—This company, of Cleveland, Ohio, has purchased the Cleveland and Elgin factories of the Federal Manufacturing Company, and will continue to manufacture railway curtains and curtain fixtures. Mr. Arthur L. Garford is president of the company. The capital stock is $400,000, and by this transfer the liquidation of the Federal Manufacturing Company is completed.

Davis Expansion Boring Tool.—Mr. Mord Roberts, who was well known in his railroad career, has entered the field of manufacturing railroad appliances as general manager of the Davis Expansion Boring Tool Company, 202 S. Commercial street, St. Louis, Mo. Mr. Roberts' reputation is itself sufficient guarantee of the value of the Davis tools, which are specially adapted to use in boring mills, lathes and drill presses. Those interested in improving their shop output may communicate with Mr. Roberts at the address given.

Wm. B. Scaife & Sons Company.—The plant of the Driggs-Seabury Ordinance Corporation at Sharon, Pa., which was designed, manufactured and erected by Wm. B. Scaife & Sons Company of Pittsburgh, is almost completed and consists of a foundry, 100 by 440 ft.; forge shop, 109 by 160 ft.; machine shop, 60 by 260 ft.; power-house, 40 by 180 ft., and shell building, 160 by 250 ft.; all of steel frame construction. They have also designed and erected a mill building, 172 by 78 ft., of steel frame construction, covered with corrugated iron, for the Broomal Iron & Steel Company, Belington, W. Va., and have been awarded contracts by the American Lime & Stone Company for a steel frame trestle to be erected at Bellefonte, Pa., and a steel frame tipple about 400 ft. long for their Buffalo Run plant.

A Large Order for Cars.—The Baltimore & Ohio has awarded a contract of approximately $12,000,000 for 10,000 freight cars, 2,000 steel hoppers to be built at Berwick, Pa., and 250 refrigerators at Chicago by the American Car & Foundry Company; the Pressed Steel Car Company will build 2,000 steel coal cars; the Western Steel Car & Foundry Company, Chicago, will build 1,000 box cars; the Standard Steel Car Company will build 1,500 composite gondolas; the Cambria Steel Car Company 2,000 gondolas and the Rodger Ballast Car Company 250 ballast cars. With the recent large order for locomotives, the equipment orders placed by the Baltimore & Ohio last month aggregate approximately $16,000,000. This car order is believed to be the largest order placed at one time.

Erie Heating Company.—Mr. William White, who was formerly master mechanic of the Lake Erie & Western at Lima, Ohio, has become associated with the Erie Heating Company Railway Exchange, Chicago, and has given his attention to the improved roundhouse facilities for boiler washing and steam heating in connection with the system which this company developed and applied recently to the new round house of the Lake Shore & Michigan Southern Railway at Elkhart, Ind. Mr. White's railroad experience and wide acquaintance are exceedingly valuable assets in introducing apparatus of this kind, where an intimate knowledge of railroad conditions is necessary. The efforts of this company lie in the direction of improved roundhouse facilities, than which there is nothing more important to-day in the railroad operating problem.

Fishing in New England.—Those who have not taken a holiday for the spring fishing need to be reminded of the opportunities offered by New England, which are reported to be exceedingly good this year for the "wise man's sport." Lake Winnipesaukee for bass, cusk, pickerel and trout. New Found Lake for land-locked salmon. Lake Sunapee and the Connecticut lakes supply excellent reports of sport this season. In Vermont, Lakes Memphremagog, Champlain and Willoughby furnish attractive fishing stories, and in Maine Sebago, Rangeley, Moosehead, Grand Lake and the other 1,600 ponds and lakes are calling to the angler. A 2-cent stamp sent to the general passenger department of the Boston & Maine Railroad, Boston, Mass., will bring a booklet entitled "Fishing and Hunting," which is worth while for any sportsman to take the trouble to secure. The first salmon in the famous Bangor Pool was landed twenty minutes after the law was off on April 1. The fishermen started at Bangor Pool at 12.01 A. M. on that day and the fishing season went on in earnest. Reports indicate that the salmon and trout fishing is excellent this year in the lakes and ponds of Maine, including the Rangeleys, Sebago, Moosehead and the Dead River region.

The American Steel Foundries.—This concern has just been awarded a contract by the Norfolk & Western Railway for body and truck bolsters for 4,000 cars of different designs and capacities. These cars will be built at the Roanoke shops of the railroad company, and by the various car builders. The bolsters for all of these cars will be made entirely of cast steel, and the fact that this large order has been awarded to one company is significant of the good opinion of cast steel for this purpose. The American Steel Foundries have moved their general offices from 74 Broadway, New York, to No. 42 Broadway. The district manager's office has been moved from Alliance, Ohio, to Sharon, Pa., where new office buildings are being erected. This company has received an order from the Atchison, Topeka & Santa Fe Railway for 2,000 cast steel truck bolsters for 1,000 combination stock and coke cars, to be built by the American Car & Foundry Company; also orders for 1,000 truck bolsters to be applied to box cars for the Great Northern Railway; cast steel truck and body bolsters for 2,000 Detroit Southern Railroad cars; R. E. Janney couplers for 1,500 Chesapeake & Ohio cars and for 3,000 Lehigh Valley cars, and approximately 15 tons of steel castings for each of 250 Baltimore & Ohio locomotives to be built by the Baldwin Locomotive Works.

AMERICAN RAILWAY APPLIANCE EXHIBITION.

The following list presents the names of firms and others who are members or exhibitors of the exhibition held in connection with the International Railway Congress in Washington May 3 to 14:

Acme White Lead & Color Works, Detroit, Mich.; Adams & Westlake Co., Chicago, Ill.; Ajax Manufacturing Co., Cleveland, O.; Ajax Metal Co., Philadelphia, Pa.; American Brake Co., St. Louis, Mo.; American Brake Shoe & Foundry Co., Mahwah, N. J.; American Bridge Co., Pittsburg, Pa.; American Car & Foundry Co., New York and St. Louis; American Engineer and Railroad Journal, New York; American Hoist & Derrick Co., St. Paul, Minn.; American Iron & Steel Manufacturing Co., Lebanon, Pa.; American Lock Nut Co., Boston, Mass.; American Locomotive Appliance Co., Washington, D. C.; American Locomotive Co., New York; American Machinery Co., Willoughby, O.; American Radiator Co., Chicago, Ill.; American Railway Supply Co., New York; American Sheet & Tinplate Co., Pittsburg, Pa.; American Steam Gauge & Valve Mfg. Co., Boston, Mass.; American Steel Foundries, New York; American Steel & Wire Co., Pittsburg, Pa.; American Trackbarrow, Lowell, Mass.; American Valve & Meter Co., Cincinnati, O.; American Water Softener Co., Philadelphia, Pa.; J. S. Andrews & Co., New York; Anglo-American Varnish Co., Newark, N. J.; Appleton Car Mover Co., Appleton, Wis.; Armstrong Bros. Tool Co., Chicago, Ill.; Art Metal Construction Co., Jamestown, N. Y.; Ashcroft Mfg. Co., New York; Ashton Valve Co., Boston, Mass.; Atha, Benjamin & Co., Newark, N. J.; Atlas Portland Cement Co., New York; Aurora Automatic Machine Co., Aurora, Ill.; Automatic Valve Grinding Machine Co., Knoxville, Tenn.; Automatic Ventilator Co., New York; Charles Whiting Baker, New York; William C. Baker, New York; Baldwin Locomotive Works, Philadelphia, Pa.; Barbour Stockwell Co., Cambridgeport, Mass.; Barker Mail Crane Co., Clinton, Iowa; Barney & Smith Car Co., Dayton, O.; Barnett Equipment Co., Newark, N. J.; Lindon W. Bates, New York; Beaver Dam Malleable Iron Co., Beaver Dam, Wis.; Beckwith-Chandler Co., New York; Belle City Malleable Iron Co., Racine, Wis.; Berry Bros. Ltd., Detroit, Mich.; C. H. Besley & Co., Chicago, Ill.; Bethlehem Steel Co., South Bethlehem, Pa.; Bettendorf Axle Co., Davenport, Iowa; Wm. T. Bonner Co., Boston, Mass.; Booth Water Softening Co., New York; L. J. Bordo Co., Philadelphia, Pa.; S. F. Bowser & Co., Fort Wayne, Ind.; Bradford Draft Gear Co., Bradford, Ill.; Bradley, Osgood & Sons, Worcester, Mass.; Brady Brass Co., Jersey City, N. J.; Bridgeport, Conn.; J. G. Brill Co., Philadelphia, Pa.; Harold P. Brown, New York; Brown & Co., Inc., Pittsburg, Pa.; Brown Hoisting Machinery Co., Cleveland, O.; Bryant Electric Co., Bridgeport, Conn.; Buckeye Steel Castings Co., Columbus, O.; Bucyrus Co., South Milwaukee, Wis.; Buda Foundry & Mfg. Co., Chicago, Ill.;

Buffalo Forge Co., Buffalo, N. Y.; Bullard Machine Tool Co., Bridgeport, Conn.; Burnham, Williams & Co., Philadelphia, Pa.; Butler Drawbar Attachment Co., Cleveland, O.; Cambria Steel Co., Philadelphia, Pa.; Camel Co., Chicago, Ill.; Carbon Steel Co., New York; Philip Carey Mfg. Co., Cincinnati, O.; Carnegie Steel Co., Pittsburg, Pa.; Chenoweth & McNamee, Brooklyn, N. Y.; Chicago Car Heating Co., Chicago, Ill.; Chicago-Cleveland Car Roofing Co., Chicago, Ill.; Chicago Pneumatic Tool Co., Chicago, Ill.; Chicago Railway Equipment Co., Chicago, Ill.; Chicago Varnish Co., Chicago, Ill.; Chilton Paint Co., New York; Cleveland Car Specialty Co., Cleveland, O.; Cleveland City Forge & Iron Co., Cleveland, O.; Cleveland Frog & Crossing Co., Cleveland, O.; Cling Surface Co., Buffalo, N. Y.; W. H. Coe Mfg. Co., Providence, R. I.; Columbia Fire Cracker Co., Bucyrus, O.; Columbia Nut & Bolt Co., Inc., Bridgeport, Conn.; Commonwealth Steel Co., St. Louis, Mo.; J. B. & J. M. Cornell Co., New York; Consolidated Car Heating Co., New York; Consolidated Cross-Tie Co., New York; Consolidated Railway Electric Lighting & Equipment Co., New York; Consolidated Safety Valve Co., New York; Continuous Rail Joint Co. of America, Newark, N. J.; Continuous Rail & Mfg. Co.; Indianapolis, Ind.; W. W. Converse & Co., Palmer, Mass.; Cooper Hewitt Electric Co., New York; Crago & Bohrnstedt, Cadotte, Wis.; Crane Co., Chicago, Ill.; Crocker-Wheeler Co., Ampere, N. J.; Curtain Supply Co., Chicago, Ill.; Damascus Brake Beam Co., St. Louis, Mo.; Damascus Bronze Co., Pittsburg, Pa.; Davis Expansion Tool Boring Co., St. Louis, Mo.; John Davis, Co., Chicago, Ill.; Davis Pressed Steel Co., Wilmington, Del.; Dearborn Drug & Chemical Co., Chicago, Ill.; Detroit Lubricator Co., Detroit, Mich.; Detroit Seamless Tube Co., Detroit, Mich.; F. W. Devoe & C. T. Reynolds Co., New York; Diamond Rubber Co., Akron, O.; Paul Dickinson, Chicago, Ill.; Dilworth, Porter & Co., Pittsburg, Pa.; Draper Mfg. Co., Port Huron, Mich.; Dreses Machine Tool Co., Cincinnati, O.; Dressel Railway Lamp Works, New York; Duff Mfg. Co., Pittsburg, Pa.; Dukesmith Air Brake Co., Pittsburg, Pa.; Eastern Granite Roofing Co., New York; Edison Mfg. Co., New York; Edna Smelting & Refining Co., Cincinnati, O.; O. M. Edwards Co., Syracuse, N. Y.; Electric Controller & Supply Co., Cleveland, O.; Electric Storage Battery Co., Philadelphia, Pa.; Electro-Dynamic Co., Bayonne, N. J.; Elliott-Fisher Co., Philadelphia, Pa.; Elliott Frog & Switch Co., East St. Louis, Ill.; Empire Safety Tread Co., Brooklyn, N. Y.; Ewald Iron Co., St. Louis, Mo.; Fairbanks, Morse & Co., Chicago, Ill.; Falls Hollow Staybolt Co., Cuyahoga Falls, O.; Farlow Draft Gear Co., Baltimore, Md.; Federal Co., Chicago, Ill.; Federal Mfg. Co., Elyria, O.; Flannery Bolt Co., Pittsburg, Pa.; Flood & Conklin Co., Newark, N. J.; Foote, Burt & Co., Cleveland, O.; Foster Engineering Co., Newark, N. J.; Walter H. Foster, New York; Franklin Mfg. Co., Franklin, Pa.; Franklin Railway Supply Co., Franklin, Pa.; Frost Railway Supply Co., Detroit Mich.; Fuller Bros. & Co., New York; Galena Signal Oil Co., Franklin, Pa.; Garlock Packing Co., New York; Harney J. Gehr, Waynesboro, Pa.; General Electric Co., New York; General Railway Signal Co., Buffalo, N. Y.; German-American Car Lines, Chicago, Ill.; Gold Car Heating & Lighting Co, New York; Wm. Goldie, Jr., & Co., West Bay City, Mich.; Goldschmidt, Thermit Co., New York; Goodwin Car Co., New York; Gould Coupler Co., New York; Greenlee Bros. & Co., Rockford, Ill.; Griffin Wheel Co., Chicago, Ill.; Grip Nut Co., Chicago, Ill.; Hageman Metallic Hose Co., Chicago, Ill.; Hale & Kilburn Mfg. Co., Philadelphia, Pa.; Hall Signal Co., New York; Handlin-Buck Mfg. Co., St. Louis, Mo.; Hart Steel Co., New York; Hartford Rubber Works Co., Hartford, Conn.; N. L. Hayden Mfg. Co., Columbus, O.; Heath & Milligan Mfg. Co., Chicago, Ill.; Hendy Machine Co., Torrington, Conn.; Hess-Bright Mfg. Co., Philadelphia, Pa.; Hewitt Mfg. Co., Chicago, Ill.; Heywood Bros. & Wakefield Co., Wakefield, Mass.; Hill, Clarke & Co., Boston, Mass.; Home Rubber Co., Trenton, N. J.; Homestead Valve Mfg. Co., Pittsburg, Pa.; Hubbard & Co., Pittsburg, Pa.; Hunt-Spiller Mfg. Corporation, South Boston, Mass.; Hussey-Binns Shovel Co., Pittsburg, Pa.; C. B. Hutchins & Sons, Detroit, Mich.; Illinois Steel Co., Chicago, Ill.; Independent Railroad Supply Co., Chicago, Ill.; Industrial Works, Bay City, Mich.; Ingersoll-Sergeant Drill Co., New York; Ingoldsby Automatic Car Co., St. Louis, Mo.; International Correspondence Schools, Railway Department, Chicago, Ill.; International Creosoting & Construction Co., Galveston, Tex.; International Fence & Fireproofing Co., Columbus, O.; International Nickel Co., New York; *International Railway Journal*, Philadelphia, Pa.; Interstate Engineering Co., Bedford, O.; Iron City Tool Works, Pittsburg, Pa.; A. H. Jackson, Fremont, O.; Jenkins Bros., New York; W. H. Johns-Manville Co., New York; J. R. Johnson & Co., Richmond, Va.; Jones & Laughlin Steel Co., Pittsburg, Pa.; B. M. Jones & Co., Boston, Mass.; Philip S. Justice & Co., Philadelphia, Pa.; Kalamazoo Railway Supply Co., Kalamazoo, Mich.; Keefer Railway Tie Co., Cincinnati, O.; Keith Mfg. Co., Sagamore, Mass.; Thomas Kendrick, Glenwood Springs, Col.; Kennicott Water Softener Co., Chicago, Ill.; Edwin R. Kent & Co., Chicago, Ill.; Kerr Turbine Co., Wellsville, N. Y.; Keystone Lantern Co., Philadelphia, Pa.; King-Lawson Car Co., Middletown, Pa.; Kinsman Block System Co., New York; Krips-Mason Machine Co., Philadelphia, Pa.; Lackawanna Steel Co., New York; Landis Machine Co., Waynesboro, Pa.; Landis Tool Co., Waynesboro, Pa.; Lawrence Switch Co., Duluth, Minn.; Lehigh Portland Cement Co., Allentown, Pa.; C. Lembecke & Co., New York; J. S. Leslie, Paterson, N. J.; Gustav Lindenthal, New York; Lock Joint Pipe Co., New York; Locomotive Appliance Co., Chicago, Ill.; Lodge & Shipley Machine Tool Co., Cincinnati, O.; Lorain Steel Co., Philadelphia, Pa.; Lord Electric Co., Boston, Mass.; F. H. Lovell & Co., New York; Lowe Bros. Co., Dayton, O.; John Lucas & Co., Philadelphia, Pa.; Lukens Iron & Steel Co., Coatesville, Pa.; Lunkenheimer Co., Cincinnati, O.; MacLeod, Walter & Co., Cincinnati, O.; Madeira, Hill & Co., Philadelphia, Pa.; Magnus Metal Co., Buffalo, N. Y.; Mahoney Railroad Ditching Machine Co., Vincennes, Ind.; A. Major, New York; Manning, Maxwell & Moore, New York; Manufacturing Co., Carlisle, Pa.; Maryland Steel Co., Philadelphia, Pa.; Mason Regulator Co., Boston, Mass.; John W. Masury & Son, New York; Matthews-Northrup Works, Buffalo, N. Y.; McConway & Torley Co., Pittsburg, Pa.; McCord & Co., Chicago, Ill.; Mechanical Rubber Co., Chicago, Ill.; Mechanical Rubber Works, Cleveland, O.; Merrill-Stevens Mfg. Co., Kalamazoo, Mich.; Merritt & Co., Philadelphia, Pa.; Middletown Car Works, Middletown, Pa.; Midvale Steel Co., Philadelphia, Pa.; Miller Anchor Co., Norwalk, O.; W. H. Miner Co., Chicago, Ill.; Monarch Coupler Co., Detroit, Mich.; Moran Flexible Joint Co., Louisville, Ky.; Modern Frog & Crossing Works, Chicago, Ill.; Morse Code (Telegraph) Signal Co., Milwaukee, Wis.; Morse Twist Drill Co., New Bedford, Mass.; Municipal Engineering & Contracting Co., Chicago, Ill.; Murphy Varnish Co., Newark, N. J.; Nathan Mfg. Co., New York; National Lock Washer Co., Newark, N. J.; National Malleable Castings Co., Cleveland, O.; National Meter Co., New York; National Railway Publication Co., New York; National Surface Guard Co., Chicago, Ill.; National Tube Co., Pittsburg, Pa.; Nernst Lamp Co., Pittsburg, Pa.; New Jersey Tube Co., Newark, N. J.; Newman Clock Co., Chicago, Ill.; New York Air Brake Co., New York; New York Belting & Packing Co., New York; George P. Nichols & Bro., Chicago, Ill.; Niles-Bement-Pond Co., New York; Norfolk Creosoting Co., Norfolk, Va.; Norton Grinding Co., Worcester, Mass.; Odenkirk Switch & Signal Co., Cleveland, O.; Ohio Injector Co., Chicago, Ill.; Oil & Waste Saving Machine Co., Philadelphia, Pa.; David E. Olds, Newark, N. J.; Old Dominion Iron & Nail Works, Richmond, Va.; Oliver Machinery Co., Grand Rapids, Mich.; Otto Gas Engine Works, Chicago, Ill.; Pantasote Co., New York; Patterson Sargent Co., Cleveland, O.; Peerless Rubber Mfg. Co., New York; Pennsylvania Steel Co., Philadelphia, Pa.; Perry Side Bearing Co., Joliet, Ill.; Pettibone, Muliken & Co., Chicago, Ill.; Pitt Car Gate Co., New York; Pittsburg Spring & Steel Co., Pittsburg, Pa.; H. K. Porter & Co., Pittsburg, Pa.; Pratt & Lambert, New York; Pratt & Letchworth Co., Buffalo, N. Y.; Pressed Car Steel Co., New York; Prosser, Thomas & Son, New York; Protectus Co., Philadelphia, Pa.; Pyle-National Electric Headlight Co., Chicago, Ill.; Quaker City Rubber Co., Philadelphia, Pa.; *Railroad Gazette*, New York; Railroad Supply Co., Chicago, Ill.; *Railway Age*, Chicago, Ill.; *Railway and Locomotive Engineering*, New York; Railway Appliances Co., Chicago, Ill.; Railway Equipment & Publication Co., New York; Railway List Co., Chicago, Ill.; *Railway Master Mechanic*, Chicago, Ill.; Railway Materials Co., Chicago, Ill.; *Railway and Engineering Review*, Chicago, Ill.; Railway Steel-Spring Co., New York; Ralston Car Co., Chicago, Ill.; Ramapo Iron Works, Hillburn, N. Y.; Rand Drill Co., New York; Raymond Concrete Pile Co., Chicago, Ill.; F. E. Reed Co., Worcester, Mass.; Arthur E. Rendle, New York; Robins Conveying Belt Co., New York; Rockwell Engineering Co., New York; Roger Ballast Car Co., Chicago, Ill.; Rostand Mfg. Co., New Haven, Conn.; G. Rouy, New York; Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.; Safety Car Heating & Lighting Co., New York; St. Louis Car Co., St. Louis, Mo.; St. Louis Car Wheel Co., St. Louis, Mo.; St. Louis Expanded Metal Fireproofing Co., St. Louis, Mo.; St. Louis Malleable Casting Co., St. Louis, Mo.; Schoen Steel Wheel Co., Philadelphia, Pa.; Scranton Bolt & Nut Co., Scranton, Pa.; Scullin-Gallagher Iron & Steel Co., St. Louis, Mo.; Seitz Bros., Tiffin, O.; Wm. Sellers & Co., Inc., Philadelphia, Pa.; Shewin-Williams Co., Cleveland, O.; Simmons Hardware Co., St. Louis, Mo.; Simplex Railway Appliance Co., Chicago, Ill.; M. A. Singer, New York; James B. Sipe & Co., Allegheny, Pa.; Smith Boltless Rail Joint Co., Homestead, Pa.; Edward Smith & Co., New York; John G. Snyder, Altoona, Pa.; South Atlantic Car & Mfg. Co., Waycross, Ga.; Southern Exchange Co., New York; Spaulding Print Paper Co., Boston, Mass.; Sprague Electric Co., New York; N. Stafford Co., New York; Standard Coupler Co., New York; Standard Paint Co., New York; Standard Sectional-Automatic Car Journal Lubricator, New York; Standard Steel Works, Philadelphia, Pa.; Star Brass Mfg. Co., Boston, Mass.; A. C. Stiles Metal Co., New Haven, Conn.; Storrs Mica Co., Oswego, New York; S. H. Summerscales, Winnipeg, Canada; Swan & Finch Co., New York; T. H. Symington Co., Baltimore, Md.; Talmage Mfg. Co., Cleveland, O.; J. Thiollier, New York; Thomas Tanty Co., New York; Trojan Car Coupler Co., New York; Trussed Concrete Steel Co., Detroit, Mich.; Tyler Tube & Pipe Co., New York; H. B. Underwood & Co., Philadelphia, Pa.; Underwood Typewriter Co., New York; Union Spring & Mfg. Co., Pittsburg, Pa.; Union Steel Casting Co., Pittsburg, Pa.; Union Switch & Signal Co., Pittsburg, Pa.; United Injector Co., New York; United & Globe Rubber Mfg. Co., Trenton, N. J.; United States Light & Heating Co., New York; United States Metal & Mfg. Co., New York; United States Steel Products Export Co., New York; Universal Railway Supply Co., Baltimore, Md.; Vacuum Cleaner Co., New York; Valentine & Co., New York; W. T. Van Dorn Co., Chicago, Ill.; Verona Tool Works, Pittsburg, Pa.; Victor Stoker Co., Cincinnati, O.; J. H. Walters, Augusta, Ga.; Washburn Co., Minneapolis, Minn.; Weber Railway Joint Mfg. Co., New York; Wellman & Street, New York; Wellman-Seaver-Morgan Co., New York; Wells Light Mfg. Co., New York; West Disinfecting Co., New York; Western Steel Car & Foundry Co., Chicago, Ill.; Western Tube Co., Kewanee, Ill.; Western Wheel Scraper Co., Aurora, Ill.; Westinghouse Air Brake Co., Pittsburg, Pa.; Westinghouse Automatic Air & Steam Coupler Co., Pittsburg, Pa.; Westinghouse, Church, Kerr & Co., New York; Westinghouse Electric & Mfg. Co., Pittsburg, Pa.; Westinghouse Machine Co., East Pittsburg, Pa.; Westinghouse Traction Brake Co., Pittsburg, Pa.; Wm. Wharton, Jr., & Co., Inc., Philadelphia, Pa.; Wheel Truing Brake Shoe Co., Detroit, Mich.; White Enamel Refrigerator Co., St. Paul, Minn.; Williams, Brown & Earle, Philadelphia, Pa.; James G. Wilson Mfg. Co., New York; G. S. Wood, Chicago, Ill.; R. O. Wood & Co., Philadelphia, Pa.; Wymen & Gordon, Worcester, Mass.; Yale & Towne Mfg. Co., New York; Yawman & Erbe Mfg. Co., Rochester, N. Y.; Yetman Transmitting Typewriter Co., New York.